The Results of Sockeye Salmon *Oncorhynchus nerka* Stocking into Spiridon Lake on the Kodiak National Wildlife Refuge: Juvenile and Adult Production, Commercial Harvest, and Ecosystem Effects, 1987-1996

By

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EXECUTIVE SUMMARY

Stocking of barren lakes is a relatively new approach to increase adult production of sockeye salmon *Oncorhynchus nerka* in Alaska. Spiridon Lake, a barren system located within the Kodiak National Wildlife Refuge (KNWR) on Kodiak Island, was first stocked with a small number (<300,000) of sockeye salmon fry by the Alaska Department of Fish and Game (ADF&G) in 1990. Pillar Creek Hatchery was constructed near the City of Kodiak in 1990 and a pipeline was installed on the outlet of Spiridon Lake in 1991 to bypass smolt past a series of barrier falls. These projects enabled a more extensive sockeye fry stocking program to be initiated by ADF&G and the Kodiak Regional Aquaculture Association (KRAA). The intent of this program was to provide adult returns for primary harvest in traditional fisheries of the Northwest Kodiak District and secondarily in the Spiridon Bay Terminal Harvest Area (SBTHA). Fisheries and limnological investigations prior to fry stocking determined that the lake was capable of rearing ~ 11 million fry; however, due to the concerns with the fragile nature of barren systems a gradual approach to stocking was recommended. Fry stocking has ranged from 2.2 million to 5.7 million fry from 1991-1996.

Fisheries and limnological monitoring and evaluation studies have been ongoing at Spiridon Lake and Spiridon Bay since the inception of the project in order to comply with the U.S. Fish and Wildlife Service (FWS) guidelines as developed from the Environmental Assessment (EA) and the resultant Finding of No Significant Impact (FONSI). These studies include: Assessing the nutrient and zooplankton base in the lake; Monitoring the size and age of outmigrating sockeye salmon smolt; Determining and monitoring the size characteristics of resident juvenile and adult Dolly Varden char *Salvelinus malma* in the lake; Determining the indexed pink *O. gorbuscha*, chum *O. keta*, and coho *O. kisutch* salmon escapement into Spiridon River; Determining the total returns by age class of Spiridon Lake bound sockeye salmon; Documenting seabird, marine mammal, and waterfowl activity on inner Spiridon Bay; and Monitoring brown bear *Ursus arctos middendorffi* activity patterns in response to smolt camp and fish returns in Spiridon Bay. In addition, the evaluation of Saltery Lake sockeye as an alternative brood stock for the project (late run Upper Station is the primary brood stock) was conducted; primarily to determine if this stock would be compatible with existing KNWR policy.

Limnological studies revealed minimal impacts from fry stocking. Water chemistry, dissolved nutrients and chlorophyll *a* levels have remained stable and characteristic for an oligotrophic-type lake. Total phosphorus and nitrogen concentrations showed little variation and the mean TN:TP ratios for year of stocking (230:1 in 1996) were similar to pre-stocking years (198:1). Total mean macrozooplankton (TMZ) density and biomass averaged slightly less for stocking years (7,353 animals m^3 and 19 mg m^3) than pre-stocking years (8,047 animals m^3 and 21 mg m^3); however, did not appear to be substantially reduced by stocking. The density and biomass of *Diaptomus* and *Bosmina* declined during years fry were stocked, as compared to pre-stocking years, whereas *Cyclops* density and biomass increased during stocking years. These changes are likely due to natural cycles which are common, especially for copepods. Sizes for these species have remained relatively large, indicating little size-selective predation pressure by juvenile sockeye. Limnological parameters have remained within the EA criteria with the exception of the cladoceran to copepod ratio which was not to exceed 0.17:1. In 1995 and 1996, this ratio was 0.30 and 0.35, respectively.

This variation in the composition of cladocerans and copepods is probably not related to stocking; the increase in cladocerans is a good indicator that allochthonous fertility rather than predation impacts influenced this ratio.

Fry-to-smolt survival has averaged 28.8% and age-at-migration has been predominantly age-1 fish. The largest smolt migration was in 1992 when 1.5 million smolt were enumerated while the lowest was in 1993 when 346,000 smolt emigrated. The smolt bypass system has performed well with mortality averaging 2.0% since 1993. The average size of age-1 smolt has exceeded EA criteria (5 g and 85 mm) for all years.

Run reconstruction, using identification of freshwater growth characteristics on scales, was implemented in 1994 when the initial harvest of Spiridon Lake-bound sockeye occurred. That year, ~264,000 sockeye were harvested, primarily with the Northwest Kodiak District. The majority of sockeye were harvested within the SBTHA (44%), followed by Uyak Bay (30%), and Uganik Bay (26%). In 1995, ~97,000 sockeye were harvested with 36% caught in Uganik Bay, 31% in Uyak Bay, and 33% in SBTHA. The 1996 harvest was 387,000 sockeye; 40% in Uganik Bay; 16% in Uyak Bay; and 42% in the SBTHA. The harvest timing has paralleled the escapement timing of the brood stock (Upper Station) for all years; peak harvest occurring from the second to third weeks of August. Overall survival for the fry stocked in 1991 was 7.9%; marine survival was 17.4% and appears higher (29-40%) for 1992 and 1993 stocking years.

The incidental harvest of salmon within the SBTHA was 30,337 pinks, 297 chums, and 2,590 coho in 1994. Escapement indices for Spiridon River indicated that minimum goals were not met that year. Consequently, the SBTHA was reduced in size in 1995 to include only Telrod Cove proper. The incidental harvest of pink salmon as a proportion of the total catch of statistical areas 254-40 and 254-50 declined and targeted escapement goals were met in Spiridon River in 1995. Chum salmon incidental harvest increased in 1995; however, minimum escapement goals were met in Spiridon River. In 1996, incidental harvest in SBTHA was 42,705 pink salmon, 2,688 chum salmon, and 1,626 coho salmon. Spiridon River minimum escapement goals for pink and chum salmon were not met in 1996; however, runs were poor that year. Coho salmon minimum escapement goals were met from 1994-1996. Aerial estimates of escapement into Spiridon River are subject to bias due to poor visibility; thus, escapement indices may be under-represented.

Saltery Lake sockeye may be a more appropriate brood stock than late run Upper Station sockeye for the Spiridon Lake project due to earlier run timing, availability of spawners, cost effectiveness, and fish culture benefits. Spiridon-bound adults with Saltery Lake run timing (peaking ~22 July) would likely reduce incidental harvest of Spiridon River stocks, and improve escapement of sockeye to Little Kitoi Lake for the brood stock development program at Kitoi Bay Hatchery; both as result of fewer sockeye returning when pink salmon harvest is high. Disease risks to Spiridon River chum salmon are not expected to be any higher or lower if Saltery Lake sockeye are used as brood stock rather than Upper Station stock.

INTRODUCTION

Lake systems in Alaska with impassable outlets, limiting access to anadromous fish, have not often been stocked with sockeye salmon *Oncorhynchus nerka* juveniles (Kyle 1996). The stocking of these "barren lakes" to increase adult production is a relatively new approach to sockeye salmon enhancement. The intent of barren lake stocking programs is to rear juvenile sockeye in under utilized freshwater habitat to produce smolts on a sustained basis without substantially changing the nutrient balance or forage base (macrozooplankton). Stocking of barren lakes may also provide opportunity to reduce or prevent negative interactions with wild stocks; direct harvests of adults to specified (terminal) areas; and to thoroughly assess the response of macrozooplankton to stocking (Kyle 1996).

Barren lakes within the Kodiak Island Archipelago have been stocked with sockeye salmon since the 1950's. A sockeye salmon enhancement project was initiated by the Alaska Department of Fish and Game (ADF&G) in the 1960's by transplanting adult and juvenile sockeye into barren Frazer Lake (Blackett 1979; Kyle et al. 1988; Figure 1). These transplants in conjunction with construction of a fish ladder have resulted in a self sustaining run of sockeye salmon. More recent (1990's) sockeye salmon enhancement projects on the Kodiak Island Archipelago have been initiated by stocking juveniles in barren systems to create terminal harvest of all returning adults. These stocking projects include Little Waterfall Lake (Edmundson et al. 1994), and Hidden Lake (White 1992; Honnold et al. *in press*), on Afognak Island, and Spiridon Lake (Kyle et al. 1990) on Kodiak Island proper (Figure 1). Of these, the Spiridon Lake project employs fry stocking and a smolt bypass system to produce adult sockeye salmon which can be harvested in traditional fishing areas and a terminal harvest area in Telrod Cove (Figure 2 and 3).

Spiridon Lake is located on the west side of Kodiak Island (approximately 74 km southwest of the city of Kodiak) and lies within the Kodiak National Wildlife Refuge (KNWR; Figure 1). It is the third largest lake on Kodiak Island and drains into Telrod Cove and Spiridon Bay by way of Telrod Creek. Spiridon Lake does not support anadromous fish due to a series of impassable cascading falls on Telrod Creek.

Spiridon Lake was investigated by the ADF&G as a potential sockeye salmon enhancement project in the 1970's (Kyle et al. 1990). These and later studies (1980's) indicated spawning habitat limitations but identified extensive rearing habitat and an ample forage base. A suitable hatchery fry delivery system for sockeye salmon did not exist during this period; thus, initial recommendations for enhancement were limited to either building a fishpass facility on the lake outlet similar to Frazer Lake (Blackett 1987), or diverting the lake discharge into Little River to provide access for adult salmon into the lake. Neither of these enhancement options were implemented. This was primarily due to the system being located within the KNWR, which does not allow these types of salmon enhancement activities; per the dictates of the U.S. Fish and Wildlife Service (FWS). Fisheries and limnological investigations were continued on an annual basis to define the rearing capacity and potential stocking level of the lake (Kyle et al. 1990). The optimum rearing capacity based on euphotic volume (Koenings and Burkett 1987) for Spriridon Lake was determined to be approximately 11 million sockeye salmon fry (Kyle et al. 1990). In addition, the outlet falls were evaluated to determine the extent of mortality smolts would incur when emigrating from the lake. This assessment indicated excessive mortality; thus, a system to transport migrating juveniles past the falls would be needed.

Meanwhile, in the late 1980's, the Kodiak regional salmon planning team drafted the Kodiak Island Comprehensive Salmon Plan which listed Spiridon Lake sockeye salmon enhancement as a priority objective (KRPT 1987). As result, in 1990, the Kodiak Regional Aquaculture Association (KRAA) provided the construction and operational funding for a sockeye salmon culture facility (Pillar Creek Hatchery) near the City of Kodiak (Figure 1). This facility was designed primarily to culture sockeye salmon fry for stocking into barren lakes. Concurrent with the development of a central incubation facility, the ADF&G, in cooperation with KRAA, developed a strategy for Spiridon Lake enhancement. The goal of the project was to produce sockeye salmon for commercial harvest in traditional fishing areas in the Kodiak Management Area (KMA; Figure 4) and to assure that those returning adults not harvested in traditional areas would be caught in a terminal area (Figure 2) within Telrod Cove (Kyle et al. 1990).

A proposal was submitted to the FWS in 1990 detailing the sockeye salmon fry stocking program which included, brood source, pipeline and smolt bypass system construction, potential adult run size and timing, harvest areas, and other attributes. The FWS completed an environmental assessment (EA) of the project in 1991, declaring a Finding of No Significant Impact (FONSI) for the proposed stocking of sockeye salmon into Spiridon and specified the following guidelines and commitments for the project (KNWR 1991):

1) Stocking levels in the lake proceed incrementally with a full evaluation of nutrient, algal, and zooplankton responses at each stocking level. This evaluation is to be reviewed jointly by the ADF&G and FWS prior to any increase in stocking level.

2) If negative impacts to the nutrient base are detected, stocking will be terminated until the lake recovers naturally.

3) An evaluation of the population trends of resident char *Salvelinus* in the lake be determined prior to and concurrent with stocking.

4) The use of a weir or other means of preventing access for spawning fish into the Telrod Creek be discontinued from the project plan.

5) There will be increased effort to determine and evaluate escapement of natural stocks of the pink *O. gorbuscha*, chum *O. keta*, and coho *O. kisutch* salmon into Spiridon River through additional aerial surveys, a weir, or sonar counts. This increased effort would be required for a period of 3 years prior to the expected first return of project produced sockeye.

6) A general periodic survey of wildlife in Spiridon Bay be conducted from mid-July through early September for 3 years prior and 3 years after the intial returns of sockeye to the bay warrant fleet operations in the Special Terminal Harvest Area.

7) A specific number of tagged brown bear *Ursus arctos middendorffi* (<=10) which utilize the immediate area near the proposed smolt diversion camp on the Telrod Creek will be re-collared

to evaluate and recommend changes, if any, to camp operations to avoid any long-term bear/human problems. In addition, the marked bears will allow the refuge to evaluate their response to any decrease or increase in salmon abundance in the lower Telrod Creek.

The FWS required that a comprehensive monitoring plan for the project be completed by ADF&G and the Kodiak refuge (KNWR) personnel based upon the above guidelines. The final monitoring plan specified the following annual objectives:

1) Assess the nutrient and zooplankton base in Spiridon Lake.

2) Monitor the size and age of outmigrating sockeye salmon smolt.

3) Determine and monitor size characteristics of resident juvenile and adult Dolly Varden char Salvelinus malma in Spiridon Lake.

4) Determine the indexed pink, chum, and coho salmon escapement into Spiridon River.

5) Determine the total returns by age class of Spiridon Lake bound sockeye salmon.

6) Document seabird, marine mammal, and waterfowl activity on inner Spiridon Bay.

7) Monitor brown bear activity patterns in response to smolt camp and fish returns in Spiridon Bay.

Late run Upper Station sockeye salmon was selected as the brood stock for the project with the intent of providing run timing that would minimize impact on management of local wild stocks (Spiridon River) in the area. This brood stock was used for the project from 1989-1993 and 1995-1996. Saltery Lake sockeye stock was used, experimentally, in 1994 to determine if an earlier run timing would benefit the project (ADF&G 1994). Saltery Lake sockeye salmon have run timing 2-3 weeks earlier than the Upper Station sockeye stock. Routine disease screening of the Saltery Lake stock during the egg take in 1994 revealed a high incidence of Infectious Hematopoietic Necrosis Virus (IHNV). The FWS requested that ADF&G assess the change in run timing, and the potential for increased risk of IHNV to sockeye salmon, chum salmon and rainbow trout *O. mykiss* in Spiridon River. In response, the ADF&G submitted a proposal (RIR No. 4K94-44) to the FWS for temporary use (1995-1997) of Saltery Lake sockeye salmon as a brood source for the Spiridon Lake enhancement project. The FWS determined that the 1995 stocking of Saltery Lake sockeye salmon fry was compatible with refuge purposes, but would not be permitted to continue beyond 1995 until further review of the impacts of a change in brood stock were conducted. Thus, the following additional evaluation objectives were required by FWS to assess Saltery Lake sockeye salmon as brood stock for compatibility with existing KNWR policy :

1) Characterizing the incidence of IHNV in the Spiridon River sockeye and chum salmon stocks and spawning populations of rainbow trout.
2) Characterizing the genetics of those sockeye runs associated with the Spiridon Lake project - Upper Station late run, Saltery and Spiridon River.

3) Increasing the number of index surveys on Spiridon River for pink and chum salmon.

ADF&G and FWS personnel observed ~5,000 sockeye salmon and 500 pink salmon in the terminus of Telrod Creek distributed to the initial barrier falls in August 1994. In addition, significant evidence of human activity was observed, including graffiti painted on a cliff and impacts to shoreline habitat. Due to these observations, the FWS recommended moving the ADF&G monitoring camp from Anguk Island to an area on the southeast end of Telrod Cove to enhance monitoring coverage. Also, the FWS suggested that an experimental barrier net be placed in the mid-cove area of Telrod Cove, to decrease crowding of vessels during the fishery, lessen impacts to shoreline habitat and wildlife, and prevent excess sockeye salmon from escaping into Telrod Creek. The ADF&G installed a barrier net and relocated the monitoring camp in July 1995 (Figure 3). Pink salmon escapement requirements for Telrod Creek as described in the EA (~100 fish) were to be ensured by whatever means necessary. It was also requested that the ADF&G coordinate with the FWS to assure minimal impact to seabirds, waterfowl and other marine mammals in the area during operation of the net. Thus, to assess the use of the barrier seine as well as the relocation of the monitoring camp to Telrod Cove, the FWS requested ADF&G monitor:

1) The commercial catch of sockeye salmon attributed to the project.

2) The incidental catch of pink, chum and coho salmon in the SBTHA.

3) Commercial fishing activity.

4) The action taken and results to provide for pink salmon escapement (minimum goal ~ 100 pinks) into Telrod Creek.

The ADF&G, in cooperation with KRAA, has released sockeye salmon fry into Spiridon Lake, annually, since 1990. Stocking numbers have ranged from a low of 0.3 million fry (1990) to a high of 5.7 million fry (1994). The initial adult return from Spiridon Lake stocking occurred in 1994 (~267,000 sockeye salmon; Nelson and Barrett 1994). The majority of Spiridon Lake bound sockeye salmon are harvested in the Northwest Kodiak District (Figure 4) and are managed for as outlined in the Spiridon Lake Sockeye Salmon Management Plan (Prokopowich et al. 1994, 1995, 1996; Brennan et al. 1996). This includes a Terminal Harvest Area (THA) in Spiridon Bay which provides for harvest of those sockeye salmon that are not caught in traditional fishing areas of the Northwest Kodiak District (Prokopowich et al. 1994; Figure. 2). In 1995, the THA was reduced to Telrod Cove proper to provide for a more orderly fishery as well as to protect wild salmon stocks within Spiridon Bay (Prokopowich et al. 1995; Figure 3). The Spiridon Lake sockeye salmon run was approximately 97,000 and 387,000 adults in 1995 and 1996, respectively (Nelson and Swanton 1996c; Nelson and Swanton 1997).

The purpose of this report is to chronicle the initial data collection efforts conducted on this system, present the results of fry stocking by brood source as indicated by smolt emigrations and adult returns, and to document the results of the FWS monitoring requirements described above (excluding brown bear monitoring, which is managed by FWS). The intent is to provide:

1) Analysis of the impacts of fry stocking in terms of freshwater habitat responses and potential for future long term productivity.
2) Evaluation of the current brood source (Upper Station sockeye) and an alternate brood source (Saltery Lake sockeye), in terms of the effects of adult returns upon the natural ecosystem as well as the traditional commercial fishery.
3) Make recommendations for future stocking levels, brood stock modifications, and continued monitoring activities.

Description of Study Area

Spiridon Lake (57° 40' N, 153° 39' W) lies at an elevation of 136 m, is 9.6 km long, up to 1.6 km wide, and has a surface area of 9.2×10^6 m^2 (Figure 5). The lake has a mean depth of 34.7 m, a maximum depth of 82 m, and is characterized as an oligotrophic system (Kyle et al. 1990). Because of the relative depth and elevation of this lake, ice usually remains until the first of May and water temperatures are colder than most other Kodiak lakes. Runoff from Spiridon Lake flows in a southeasterly direction via the 2.4 km Telrod Creek emptying into Spiridon Bay at Telrod Cove located approximately 7.2 km northwest from the head of the bay (KNWR 1991). The watershed drains an area of approximately 60 km^2, and with a mean annual precipitation of 101.5 cm, the lake-water residence time is 7.1 years. Spiridon River is the only other major drainage in the study area and is 39 km long, flowing into Spiridon Bay. This system is glacially fed, and flows in a northwesterly direction from the interior of Kodiak Island. Spiridon Bay is ~ 22 km in length, 5.9 km wide at the mouth and 0.8 km wide at the head of the bay (KNWR 1991). Brood sources for the project include Upper Station (57^0 04' N, 154^0 15' W) and Saltery Lakes (57^0 32' N, 152^0 45' W), located ~ 145 km and 37 km south of the city of Kodiak, respectively (Figure 1).

Resident fish in Spiridon Lake include: rainbow trout, Dolly Varden char, three spine stickleback *Gasterosteus aculeatus*, and freshwater sculpin *Cottus aleuticus*. In addition, pink salmon have been observed in the terminus of Telrod Creek, as well as the adjacent intertidal area. The lake has natural populations of char; however, Rainbow trout, were reportedly introduced in the 1950's through a stocking project by the Kodiak Conservation Club (KNWR 1991). Spiridon River has natural runs of pink, chum, and coho salmon and recently the FWS identified a small run of sockeye salmon in a small lake (and tributaries) that drains into the river.

METHODS

Limnological Evaluation

Lake Sampling

A total of 52 limnological surveys were conducted on Spiridon Lake from 1987-1996. Surveys were conducted at ~4-6 week intervals during the ice free season (May-September) for a total of four to five surveys annually from 1987 through 1990. Surveys were conducted more frequently from 1991 to 1996 in conjunction with increased fry stocking; at ~4 week intervals from May through early October for a total of six to seven surveys annually. Float-equipped aircraft provided transportation to and from sampling sites. Surveys were conducted after mooring to an anchored buoys (station) established within the two deepest basins of the lake. Two additional zooplankton sampling stations were established in 1994 because of the size of Spiridon Lake (large surface area and volume). Temperature, dissolved oxygen, and light penetration were measured, and both water and plankton samples were collected at each original station (stations 1 and 2) and zooplankton only, collected at the additional stations (stations 3 and 4). The methodologies are described in detail below for each of the limnological parameters.

General Water Chemistry and Nutrients

Discrete water samples for general water chemistry and nutrient analysis were collected from the 1-m stratum and from ~75% of the maximum depth using a 6-L opaque Van Dorn sampler and emptying the contents into a pre-cleaned polyethylene (poly-) carboys. The carboys were kept in a heat and light limited environment while in the field and returned to Kodiak for filtration and preserving. Samples for color and dissolved inorganic nutrients were filtered through a rinsed 47 mm-diameter Whatman GFF cellulose fiber filter and stored frozen in phosphate free soap-washed polybottles until analysis. Unfiltered samples for the analysis of total phosphorus (TP) and Kjeldahl nitrogen (TKN) were stored frozen and unfiltered water for general water chemistry analysis stored refrigerated (4^{o} C) in clean polybottles (Koenings et al. 1987).

Conductivity was measured in the laboratory with a YSI model-32 conductance meter and the readings standardized to 25^{o} C. Salinity was calculated from temperature compensated conductivity measurements using a linear conversion (Wooster et al. 1969; Koenings et al. 1987). The pH was measured with an Orion 499A meter. Alkalinity (mg L^{-1} as $CaCO_3$) was determined from 100-ml samples titrated with 0.02 N H_2SO_4 to pH 4.5 using the pH meter (AHPA 1985). Calcium and magnesium were determined on the same sample from separate EDTA titrations as detailed by Golterman (1969). Total iron was determined colorimetrically after HCL digestion and reduction with hydroxylamine (Golterman 1969; Strickland and Parsons 1972). Turbidity, expressed as nephelometric turbidity units (NTU), was measured with a calibrated HF model DRT100 turbidimeter. Water color was calculated from the spectrophometric absorption of filtered water samples at 400 nm converted to equivalent platinum cobalt (Pt) units after Koenings et al. (1987). Filterable reactive phosphorus (FRP) was analyzed by the molybdate blue-ascorbic acid method (Murphy and Riley 1962) as modified by Eisenreich et al. (1975). Total phosphorus (TP) was analyzed after potassium persulfate digestion using the FRP procedure (Eisenreich et al. 1975). Samples for nitrate + nitrite (NO_3^- + NO_2^-) and ammonia (NH_4^+) were analyzed on a Technicon autoanalyzer using the cadmium reduction and phenylhypochlorite methods, respectively as outlined in Stainton et al. (1977). Analysis of total Kjeldahl nitrogen (TKN) utilized the acid block digestion and phenate methodology devised by Crowther et al. (1980). Soluble reactive silicon (SR-Si) concentrations were determined using the automated ascorbic acid reduction procedure (Stainton et al. 1977). Samples for particulate organic carbon (POC) analysis were filtered (sample volume usually 0.5 or 1.0 L) under low vacuum (15 psi) onto rinsed Whatman GFF filters. Filters were stored frozen in separate plexiglas slides until analyzed The wet oxidation technique with dichromate was used for POC analysis as described by Newel (1982).

Chlorophyll a

Discrete depth samples for the analysis of the algal pigment chlorophyll a (chl a) were collected as described above for water samples. For chl a analysis, 0.5 or 1.0 L of sample water was filtered through a Whatman GFF filter under 15 psi vacuum pressure. Approximately 2 ml of $MgCO_3$ were added to the final 50 ml of sample near the end of the filtration process. Filters were stored frozen in individual plexiglas slides until analyzed. Filters were ground in 90% buffered acetone using a mechanical tissue grinder and the slurry refrigerated in separate 15-ml glass centrifuge tubes for 4 hr to ensure maximum pigment extraction. Pigment extracts were centrifuged, decanted, and diluted to 15 ml with 90% acetone (Koenings et al. 1987). The extracts were analyzed fluorometrically with a Turner 112 fluorometer equipped with a F4T5B lamp and calibrated with purified chl a (Sigma Chemical). After the initial fluorescence reading, the extract was acidifed with 0.05 ml 0.2 N HCL and reread to correct for phaeophytin (Riemann 1978).

Zooplankton

Vertical zooplankton hauls from each station were collected using a 0.2-m diameter, 153 um mesh, conical net. The net was pulled manually at a constant speed (~0.5 m sec^{-1}) from just off the lake bottom or from a maximum depth of 50 m to the surface. Net contents from each tow were emptied into separate 125-ml polybottles and preserved in 10% neutralized formalin. Cladocerans and copepods were identified according to taxonomic keys in Pennak (1989) and Thorp and Covich (1991). Zooplankton were enumerated and measured in triplicate 1-ml subsamples taken with a Hansen-Stempel pipette and placed in a Sedgewick-Rafter counting chamber. Lengths of 15 animals of each species were measured to the nearest 0.01 mm and the mean body length for each taxon was calculated. Biomass was estimated from specie-specific linear regression equations between length and dry weight derived by Koenings et al. (1987).

Stocking, Smolt Bypass, Smolt Emigrations and Biological Characteristics

Fry Stocking

Sockeye salmon fry stocking began in 1990 when an experimental level (~250,000) of age-0 fry (Upper Station late run) were released into Spiridon Lake to determine whether smolt would migrate as underyearlings or hold-over (Kyle et al. 1990). Over 2 million fry were stocked in 1991 (3.3 million) and 1992 (2.2 million); planting levels increasing thereafter to approximately 4-5 million and peaking with 5.7 million stocked in 1994. In 1995 and 1996 stocking levels were just under 5 million fry. The analysis of the seasonal zooplankton density and biomass provided the basis for annual stocking plans for Spiridon Lake. Initial recommendations, suggested increasing stocking to ~8 million fry after ~ 5 million fry were stocked for two years (Kyle et al. 1990). Stocking of barren lakes systems, such as Spiridon Lake has resulted in inconsistent responses within the macrozooplankton community indicating instability (Kyle 1996). Thus, determining fry rearing capacity based on models derived from systems with established sockeye salmon runs does not appear appropriate for barren systems. Therefore, after reaching the 5 million fry level for two years (1994 and 1995), it was considered prudent to continue at this level an additional year (1996) and then assess the lake's response (zooplankton) before progressing to larger fry numbers.

The brood source for egg collection was late run Upper Station sockeye salmon for all years with the exception of 1995 (1994 BR) when Saltery Lake sockeye salmon were utilized. Eggs were transported to Pillar Creek Hatchery for incubation and rearing. Emergent fry were reared for two to four weeks and then transported by an amphibious-equipped Beaver aircraft, with an interior mounted 450-L tank, to Spiridon Lake. Fry were released randomly throughout the lake after the aircraft landed.

Smolt Bypass System Design

A bypass system was initially installed in 1992 to pass the first smolt emigrating from Spiridon Lake around the outlet falls. The bypass consisted of a smolt weir, two Canadian-type fan traps, two tanks for dewatering, one tank for enumeration and sampling, and a 756 m long 15 cm ID pipeline (Figure 6). The initial design was improved in 1993 with the addition of structural aluminum tanks, replacing lumber construction.

The face of the weir is comprised of 1.2 m by 2.4 m sheets of aluminum perforated plate ~1 cm thick with 1 cm diameter holes on 1.1 cm staggered centers.

The fan traps are made of structural aluminum angle framing and cross-bracing and are 3.7 m long with the entrance height of 1.7 m, tapering to 0.4 m at the cod-end. The entrance of the each trap is square (1.7 m), while the cod-end is 0.3 m wide by 0.4 m high. The sides and base of the trap are covered with ~1 cm thick aluminum perforated plate with 1 cm diameter holes on 1.1 cm staggered centers. The base of the trap is formed into longitudinal, V-shaped corrugations ~ 0.3 m at their highest point to increase de-watering area and trap strength.

The two de-watering tanks are also constructed of structural aluminum and each measures 2.4 m long, 1.2 m wide and 1.2 m deep. Each tank has one piece of 1 cm thick aluminum perforated plate (with the same dimensions as the sides) positioned 20 cm inside, parallel to the midstream side of the tank to increase the de-watering surface and reduced tank flow rates. The perforated plate is welded to aluminum angle that is attached to the walls of the tanks. A 10 cm by 183 cm opening on the top portion of the sides parallel to the perforated plate, allows water to flow from tanks. Each tank has a 43 x 48 cm slot at one end (upstream) and a 15 cm male camlock fitting at the opposite end. Approximately 47 m of 100 psi polyethylene, 15 cm ID (1 cm thickness) pipe is attached by camlock fitting to each dewatering tank. Pipe sections are 12.2 m long with metal flanges welded at each end and attached with bolts. The pipe leads to another tank which is used for enumeration and sampling of smolts. The pipes are open ended at the counting tank with both pieces resting on the lip of the tank.

The counting tank is also constructed of structural aluminum and is 3.0 m long, 1.2 m wide, and 1.2 m deep. One end (downstream) of the tank has a welded 15 cm flange and exit opening at the air-water interface plane which the initial section of pipeline (same dimensions as described above) is attached. The tank is permanently positioned on the stream bank on a aluminum pipe and lumber frame, just upstream of the initial barrier falls. A stand pipe is used to adjust the water level in the tank.

The pipeline, composed of pipe sections as described above, rests on the ground or is supported by cable, attached to duckbill anchors. It continues downstream past the series of falls, dropping approximately 90 meters in elevation and not exceeding a 20° decline in any location. The end of the pipeline tapers into a 30 cm ID section of pipe that is angled ~ 45° upward, extending just over the stream bank to reduce water velocity and direct smolt into the stream. The smolt negotiate a barrier falls of ~ 7 m in height prior to reaching salt water. This falls has a large deep plunge pool which prevents substantial injury to smolt.

Smolt Bypass Installation and Operation

Traps were positioned mid channel and anchored by cable to turnbuckles permanently attached to anchored duckbills on the stream bank (Figure 6). Five cm diameter pipe, in three to four m sections erected with NU-RAIL fittings, were used as a frame to secure and support the traps. Come-a-longs, secured to the overhead steel pipe cross members, were used to elevate the downstream ends of the traps.

The de-watering tanks were placed downstream of the traps and secured by cable to previously positioned duckbill anchors on the stream banks. Each trap was connected to the de-watering tanks with sections of aluminum trough measuring 231 cm long, 43 cm wide and 48 cm deep and secured with 2.5 cm diameter threaded rod run through drilled holes. Rubber and foam pipe insulation material were used to assure a tight fit between the ends of troughs and the tanks and traps.

A 36 m diversion weir was installed upstream of the traps. A frame for the weir was made from 1.5 m (legs), and 2.4 m (cross members), 5 cm diameter pipe and NU-RAIL fittings. The first lengths of perforated plate were secured to the traps and screwed in place, with each upstream piece overlapping ~ 15 cm. The base of each sheet of perforated plate was positioned on the stream bed substrate. A wooden dam, secured with sandbags, was installed where the weir met the stream banks to minimize smolt avoidance near shore. The base of the weir and the dams were lined with polypropylene (lortex) material and sandbagged to prevent smolt from escaping. Lortex was also used to line the first 18 m of the weir (starting where the trap was connected to the weir) to prevent potential injury to smolt; ~ 30 cm of the weir surface parallel to the stream water level was left exposed. Similarly, the inside of each trap was lined with tarp material and/or lortex as needed. A come-a-long was attached to the upper frame at the cod-end of each trap and to the pipe frame to provide for adjustment of stream flow into the traps and de-watering tanks.

The installation of the bypass system (late April prior to the smolt outmigration) required approximately 180 man-hours of labor. The wings of the weir were cleaned of debris and dead smolt daily. The traps were adjusted to provide optimal flow (measured subjectively, based on the movement of smolt) and minimize smolt mortality. Water and air temperatures, stream height, percent cloud cover, wind direction and velocity, and precipitation. were measured daily at the smolt site at approximately 1100 and 2300 hours. The bypass system was operated from the last week in April through the end of June, 1992-1996.

Smolt Migration Estimates

Time counts of smolt passing through the bypass system were used to estimate daily outmigration. Counts were conducted every 30 minutes from 2300 hours through 0500 hours at the "counting box" (most downstream tank), with a target count of 1,000 smolt/period. The counting period (every 1/2 hour) ranged from 1.5 minutes (minimum) to 8.0 minutes (maximum). The duration of the period was determined by the rate of smolt movement, with the minimum time used during large migrations and the maximum time used during slower smolt movements. Counts were facilitated by moving one of the entrance pipes over a catch basket submerged in the tank and using a stop watch to start and end a time period (each entrance pipe drained a separate dewatering tank). The counts were alternated between the two pipes each 30 minute period. The migration estimate (number of live, dead, and total smolt) per ½ hour was determined by: (number of smolt counted per time period) x (time period/30 minutes). Actual counts of smolt were made when migrations were slow, primarily early and late in the season. Smolt in the de-watering and counting tanks holding for more than 24 hours were estimated and then removed manually in buckets and "poured" into the entrance of the pipeline. This technique prevented excessive injury or mortality. In addition, a 6.0 m long, 1.2 m deep seine with 0.6 cm mesh was used to crowd smolt through the system when large numbers were observed holding for long periods upstream of the traps.

Smolt Age and Size

Sockeye salmon smolts emigrating from Spiridon Lake were sampled from 1991-1996 for age and size. Smolts were collected in 1991 using a fyke net placed in the outlet stream; from 1992-1996, smolts were collected randomly during nightly migrations through the bypass system. The latter method included moving the open-ended pipes that entered the counting tank, at random intervals, over a 60 cm long, 30 cm wide, and 30 cm deep perforated aluminum container to collect ~150 smolt. A random sample of 70 smolt were collected from the container for daily age and size samples. Age data were collected in lieu of size data on alternate days (two days a week). A single sampling day was the 24 hour period from noon to noon and identified by the calendar date corresponding to the first noon. Smolts were anesthetized in a tricaine methanesulfonate (MS-222) solution, measured to the nearest 1.0 millimeter (mm), weighed to the nearest 0.1 gram (g), and the ponderal index (condition coefficient K) was calculated (Bagenal 1978). In addition, a scale smear was taken from the preferred area (INPFC 1963) of each fish, placed on a glass slide, and ages were determined using a microfiche projector.

Resident Dolly Varden Char Monitoring in Spiridon Lake

From 1991-1995, juvenile and adult Dolly Varden were collected in May or June and again in August from Spiridon Lake. Two beach seine (46 m long, 1-4 m tapering width and variable size mesh) sets were made at permanent markers (fence post) at West, East and South Creeks (Figure 5); one set on each side of the marker. Also, a variable mesh gillnet (33.5 m by 2.7 m; 5.1, 2.5, 1.9, and 1.3 cm mesh sizes) was set, for a 24 hour period, ~ 50 meters offshore of West Creek, perpendicular to shore at the marker. Each gillnet set was positioned just off the bottom in 9-10 m of water with the ends anchored to the bottom and the float line ends each attached to a buoy. All

Dolly Varden collected were enumerated, weighed to the nearest 0.1 g and fork length (FL) measured to the nearest mm.

Commercial Fishery Evaluation

Monitoring Camp and Barrier Net

The commercial salmon fishery was monitored in Telrod Cove and Spiridon Bay by ADF&G personnel from mid-July to mid-September, 1994-1996. A tent camp was established on Anguk Island in 1994; however, to improve monitoring, the camp was relocated to land adjacent to Telrod Cove in 1995. (Figure 3). In mid-July, 1995 and 1996, a seine web (~2.6 cm squares) barrier net ~100 m long and ~ 7 m deep, was installed ~ 0.3 km seaward of the terminus of Telrod Creek (Figure 3). The net was deployed at low tide and set shore to shore attached by cable to cliff out croppings with come-a-longs used to keep it secure and taut. Sandbags, and chain were attached to the lead line for additional weight to keep the net in place. Additional large buoys were attached to the floats for buoyancy and to provide visibility to the vessels fishing the area. Monitoring consisted of visual checks several times daily to assure that it was "fish tight," plus at low tides, the net was cleaned of debris and repositioned if necessary. Wildlife activity was monitored during daily observations of the net. Lastly, pink salmon abundance seaward of the net was monitored. When sufficient numbers were present, a local permit holder, using a seine vessel, captured the fish and released the catch into a plastic tote filled with seawater. The fish were transported by raft shoreward over the net at high tide and released. The intent was to release a minimum of 100 pink salmon over the net to provide escapement to lower Telrod Creek.

Daily surveys were conducted in Telrod Cove and Spiridon Bay to assess sockeye salmon run strength with information relayed to the Commercial Fishery Managers at 0800 and 2000 hour radio schedules. During the fishery, vessel names, fishing location, and estimated catch by species were recorded.

Age Sampling

The Spiridon Lake sockeye salmon run was sampled in the SBTHA (statistical area 254-50) at Telrod Cove for age and length data and were assumed to represent Spiridon Lake escapement (Nelson and Swanton 1996c). In 1994 and 1995 the targeted sample size was 240 fish per week (Nelson and Swanton 1996 a). In 1996, the targeted sample size was 240 fish with a goal of sampling ~1,600 fish from 01 August through the end of the run (Nelson and Swanton 1997). In addition, 300 sockeye were sampled (three 100 fish samples) from catches near Hook Point in 1996.

The commercial sockeye salmon catches within selected areas of the Northwest and Southwest Kodiak Districts were sampled weekly for age with a targeted sample size of 600 fish per area (Nelson and Swanton 1996 a,b,c; Nelson and Swanton 1997; Figure 4).

The procedures used for age designation of escapement and catch samples are described by Nelson and Swanton (1996c; 1997).

Run Reconstruction

The sockeye salmon stocks used in the analysis of the Spiridon Lake contribution were based on historical run timing within the commercial catch areas of interest (Nelson and Barrett 1994). Stock identification was based on visual recognition of scale growth characteristics. That is, age 1.1 freshwater growth characteristics of scales from sockeye salmon sampled in the SBTHA were used as a stock-specific template for classification purposes. In addition, a maximum sample size of 200 scales were selected to establish standards for known stocks. Specific procedures are described by Nelson and Swanton (1996c; 1997). Commercially caught salmon landings from the Uganik and Uyak areas of the NW Kodiak District were queried from the fish ticket database (Nelson and Swanton 1996c; Nelson and Swanton 1997). Apportionment of the catch by week was obtained by multiplying the catch of an age class for a given week by the estimated proportion of Spiridon Lake sockeye salmon of that age class.

Catch-Per-Unit-Effort: Uganik and Uyak Bays

Data were obtained to compare pre-project (prior to 1994) to post-project (1994-1996) sockeye salmon catch-per-unit-effort for Uganik and Uyak Bays (C. Hicks, ADF&G, Kodiak, personal communication). This included landings by gear type (all species) and sockeye only for each of the fishing areas, excluding the SBTHA. The average landings by statistical week and salmon species, as well as sockeye only, were compared for the 1970-1993 verses 1994-1996 time periods.

Incidental Harvest

Lastly, incidental harvest estimates of pink, chum and coho salmon in the SBTHA are gleaned from fish ticket data from statistical area 254-50 for 1995 and 1996. Estimates for 1994 are from on site surveys by ADF&G personnel.

Spiridon River and Spiridon Bay Monitoring

Escapement Estimates

Index salmon escapement surveys were conducted by ADF&G and FWS personnel at Spiridon River (statistical area 254-401; Figure 4) via fixed wing aircraft from 1994-1996 (Figures 1 and 2). Spiridon River was surveyed for index escapements as part of ADF&G annual management operations prior to the Spiridon Lake project (Brennan et al. 1996). Pre-project and project years peak index escapement trends are provided as gleaned from ADF&G Annual Management reports and the current ADF&G database.

Telrod Creek escapement estimates are primarily from foot surveys conducted during August in the lower creek directly downstream of the most downstream barrier falls.

Wildlife Surveys

Wildlife surveys were conducted in Spiridon Bay and Telrod Cove from 1991-1996. Three surveys were conducted from mid-July to the end of August each year with the exception of 1992 when two surveys were completed. The surveys began at Clove Rock Point on the south shore and ending at Hook Point on the north shore (Figure 2). A 15-foot Boston whaler or 14-foot inflatable raft was used to traverse each transect while two observers recorded distribution and abundance of wildlife observed in the air, water, and on land. In addition, birds and other wildlife at known rookeries within the bay were counted and photographed.

Brood Stock Evaluation

Spiridon River Baseline Pathology and Genetic Sampling

Spiridon River chum salmon were sampled for incidence of IHNV on August 22, 1995. Fish were collected in a tributary to Spiridon River by beach seining (Figure 1 and 2). The target sample size was 60 spawning or post spawning fish as recommended by the ADF&G Pathology staff. High stream flows and deep water limited the collection to 39 chum salmon. Ovarian fluid was collected from each of the 39 fish. Each fish was externally disinfected with iodiphor (Betadine), and rinsed with fresh water. A small portion of roe from each fish was allowed to volitionally exit the vent and collected in a dixie cup. Approximately 1 ml of ovarian fluid was decanted into 10 ml vials, stored on ice and shipped to the ADF&G pathology lab for analysis. Laboratory analysis consisted of processing of ovarian fluids by quantal assay on EPC and CHSE-214 cell lines at 15 C for 14 days and blindpassed for an additional 14 days (Meyers et al. 1990). The minimum level of detection equals five infectious particles/ml of pooled sample.

On September 23, 1995 the collection of ovarian samples from Spiridon River sockeye salmon was attempted. Sampling by beach seine on the shoals of "Munsey's Lake," and in a creek draining into the lake were unsuccessful due to high water levels and poor visibility. On October 17, 1995 an aerial survey by refuge staff reported 300-400 sockeye salmon holding in Munsey Lake (T.Chatto, KNWR, Kodiak, personal communication). Weather conditions prevented flying for over a week, thus precluded further sampling attempts. Rainbow trout sampling for IHNV incidence was delayed until FWS personnel completed abundance surveys in Spiridon River. In 1996, it was determined by the FWS that, due to low populations of Rainbow trout, disease sampling would be discontinued (T.Chatto, KNWR, Kodiak, personal communication).

Genetic samples from Upper Station late run sockeye salmon were collected in September 1993 at both the lower and upper lakes (Figure 1). Similarly, samples from Saltery Lake were collected in September 1994. Tissue samples were collected from 100 freshly killed fish (during brood stock collection) at each system with individual tissue removed from muscle, heart, liver and eye (fluid). The tissue from each organ was placed in cyrotubes which were frozen in liquid nitrogen. The sex of each fish was recorded. Frozen samples were shipped to the ADF&G genetics lab for processing and analysis. The samples were processed using electrophoresis and analyzed for allele frequencies (Aebersold et al. 1987; Hendry et al. 1996). Banding patterns were analyzed using standard protocol and gene nomenclature (Shaklee et al. 1990; Utter et al.

1987). Pairwise G-statistics were used to determine if the three collections were genetically distinct from each other and Hardy-Weinberg (H-W) analysis was used to investigate the ratios of heterozygotes and homozygotes as related to the allele frequencies (C. Habicht, ADF&G, Anchorage, personal communication). Finally, a phenogram (UPGM dendrogram; Sneath and Sokal 1973) was created using Nei's (1978) unbiased genetic distance to illustrate relationships between the populations. Genetic samples were not collected from Spiridon River sockeye salmon in 1995 or 1996 due to high water levels, poor visibility, and other weather and personnel constraints.

Saltery Lake Sockeye Escapement Estimates, Run Strength and Timing

The ADF&G has operated an escapement enumeration weir, approximately 0.6 km downstream of the Saltery Lake outlet stream, since 1985 (Figure 7). The weir is in operation from mid-June through mid-September, annually. ADF&G staff summarizes weir operations and escapement methodology in annual management reports (Brennan et al. 1996). The results for 1987-1996 as presented in these publications and other Kodiak Management Area (KMA) regional publications are summarized and include escapement trends, run information, and timing data.

In 1994 a tagging project was conducted to determine if the Saltery Lake sockeye salmon stock contains a component(s) that would be similar in escapement timing to late run Upper Station stock and would be a suitable replacement brood source for the Spiridon Lake Enhancement Project (Honnold et al. *in press*). Specifically, the spawning distribution and timing of Saltery Lake sockeye escapement occurring after July 15 were assessed. Each week, beginning July 18, 400 sockeye, collected randomly by trapping at the Saltery Cove weir, were tagged, in a 1-2 day period, with a color coded 30 cm "Spaghetti" floy tag. Tags were inserted in each fish with a tagging needle at a depth of approximately 0.13 cm (1/2 inch) below the base of the dorsal fin midway between the anterior and posterior ends. The needle and tag were pulled through to opposite side of the insertion point, the needle was removed from the tag, and the tag tied into a knot so that it laid, without slack, behind the dorsal fin. Each week a different colored tag was used (International Orange, Yellow, Pink, and Blue).

Surveys were conducted every 10 days, beginning August 22, at the Saltery Lake tributary creeks, the outlet creek and lake shoals (Figure 7). Tributary surveys were conducted on foot, walking upstream. All live and dead sockeye were enumerated, with tagged fish recorded. When spawning activity was observed (male and female paired, digging redds, spawning, etc.) the location of tagged sockeye, as well as color of tag, was recorded. All dead tagged fish were removed from the creek.

Lake shoals were surveyed by raft, initially, then when spawning activity was observed, sockeye salmon were collected by seining to determine the number and color of tagged fish present.

Saltery Lake Sockeye Escapement Age Sampling

Age samples of Saltery Lake sockeye salmon were collected by trapping adults at the weir site. Methods used are described by Swanton and Nelson (1994).

Saltery Lake Sockeye Pathology Sampling

Foot surveys of Saltery Lake tributaries were conducted in conjunction with egg takes in 1994-1996 (for stocking of Spiridon Lake in 1995 and Ruth Lake in 1996 and 1997) to locate spawning sockeye salmon for brood stock screening. Salmon were captured by beach seining along the lakeshore, and ripe females were partially stripped of eggs to obtain ovarian fluid. The ovarian fluid was decanted into individual centrifuge tubes and stored on ice in a cooler. A total of 60 samples were obtained for disease screenings and analyzed following procedures previously described (Meyers et al. 1990).

RESULTS

Limnological Evaluation

General Water Chemistry

The general water chemistry parameters assessed for Spiridon Lake have remained relatively static and within the oligotrophic-type range from 1988-1996 (Table 1). Variation has occurred for some sample dates in some years as indicated by high standard deviations (SD). For example, iron concentrations (range 9 to 114 ug L^{-1}) exhibited SD values as high as 232 (1991-station 1; 50 m) and 144 (1989-station 2; 50 m).

Dissolved Nutrients

Seasonal mean levels of inorganic dissolved nitrogen (ammonia and nitrate + nitrite) in the surface waters in Spiridon Lake were variable from 1988 to 1996 (Table 2). Mean seasonal ammonia concentrations in the 1-m stratum ranged from 1.5 to 9.9 ug L^{-1}. Concentrations exhibited slight vertical variation (3.5 to 12.5 ug L^{-1}). Nitrate + nitrite nitrogen in the surface samples ranged from 180.2 to 237.0 ug L^{-1} compared to a range of 187.3 to 273.4 ug L^{-1} in the hypolimnion samples.

Inorganic phosphorus concentration was quite stable for the years sampled (Table 2). Mean seasonal total filterable phosphorus (TFP) and filterable reactive phosphorus (FRP) within the 1-m stratum ranged from 0.9 to 4.8 ug L^{-1} and from 0.9 to 4.6 ug L^{-1}, respectively. Concentrations were similar within the hypolimnion.

Mean seasonal silica concentrations were also stable in the 1-m stratum ranging from 2,023 to 2,300 ug L^{-1} and in the hypolimnion, from 2,111 to 2,340 ug L^{-1} (Table 2).

Total Phosphorus and Nitrogen

Mean seasonal total phosphorus (TP) and Kjeldahl (organic nitrogen + ammonia) nitrogen (TKN) concentrations showed little variation (Table 2). Concentrations of TP within the 1-m stratum generally ranged from 2.4 to 3.9 ug L^{-1}; however, in two years (1989 station 2 and 1991 station 1) was slightly greater, exceeding 4 ug L^{-1}. The TP concentrations in the hypolimnion were similar with the highest value (6.1 ug L^{-1}) well below the 10 to 20 ug L^{-1} range characteristic of oligotrophic lakes (Honnold et al. 1996). Kjeldahl (organic nitrogen + ammonia) nitrogen (TKN) concentrations ranged from 83.2 to 114.8 ug L^{-1}.

The mean total nitrogen (TN):total phosphorus (TP) ratio (by weight) in the 1-m stratum of Spiridon Lake in 1996 was 230:1 which was slightly higher than the mean ratio prior to fry stocking of 198:1 (Kyle et al. 1990; KNWR 1991). A TN:TP ratio range (10:1 to 20:1) considered optimum, between 20:1 and 40:1 is characteristic of moderate phosphorus deficiency, and > 40:1 indicates severe phosphorous deficiency (Honnold et al. 1996).

Chlorophyll a

The mean near-surface (1-m) chlorophyll a concentration ranged from a low of 0.18 (1989-station 2) to a high of 1.02 (1995 - station 2) ug L^{-1} in Spiridon Lake (Table 2). Individual values over the growing season do not indicate any trends. Hypolimnetic chlorophyll levels were similar to the surface and both were within the criteria ($\leq$ 1.39 ug L^{-1}) stipulated by the EA (KNWR 1991).

Zooplankton Density, Biomass, and Species Composition

The total mean macrozooplankton (TMZ) density (animals m^{-3}) ranged from a low of 5,000 to a high of 9,500 and TMZ biomass (mg m^{-3}) ranged from 15 to 25 from 1987-1996 (Figure 8). TMZ density was greater for all years than the minimum EA criteria (1,620 per m^{-3}; KNWR 1991). Seasonal mean TMZ density (animals m^{-3}) and biomass (mg m^{-3}) averaged 8,047 and 21, respectively, for pre-stocking years (1987-1989; Table 3; Figure 8). By comparison, seasonal mean TMZ density (animals m^{-3}) and biomass (mg m^{-3}) averaged slightly less (7,353 and 19, respectively) for stocking years (1990-1996). Thus, TMZ density and biomass did not appear, on average, to be substantially reduced by the stocking of Spiridon Lake. Furthermore, TMZ density and has gradually increased to over 8,908 animals m^{-3} and biomass to 22 mg m^{-3} during the highest project stocking levels (1994-1996). Species specific density and biomass paralleled TMZ trends with the exception of *Diaptomus* and *Cyclops*. The average density of *Diaptomus* for years prior to stocking was 1,868 animals/m^3 compared to an average of 801 animals/m^3 during stocking years. *Cyclops* density increased from an pre-stocking average of 4,600 animals/m^3 to average 5,446 animals/m^3. The average density of *Bosmina* also appeared to change substantially (406 animals/m^3) from prestocking levels (900 animals/m^3); however, if excluding 1987 density (1,306 animals/m^3) which is much higher than other years, the average density is 698 animals/m^3. Biomass trends for these species are similar to density trends (Table 3). The above data are presented alternately as animals m^{-2} (density) and mg m^{-2} (biomass) by taxa for all years in Appendices A and B.

Zooplankton Size

The seasonal mean lengths of zooplankton taxa collected from Spiridon Lake were relatively large (Table 4) compared to lakes with resident populations of sockeye fry (G.Kyle, ADF&G, Soldotna, personal communication). The mean (1987-1996) sizes (mm) of the cladecerans

Bosmina, Daphnia, and *Holopedium* were 0.57, 0.93, and 0.84, respectively. Copepod size (mm) averaged 1.04 for *Diaptomus* and 0.76 for *Cyclops*. Thus, on average, zooplankton size for all species remained greater than the EA criteria of 55 mm (KNWR 1991). Several annual mean lengths showed substantial variation compared to the overall means; however, in general, no trends were evident in zooplankton taxa size.

Cladaceran: Copepod Ratio

The mean composition of cladocerans was 16% compared to 84% copepods in Spiridon Lake from 1987-1996 (Table 5). The cladaceran:copepod ratio averaged 0.20 and varied from 0.09 to 0.35 during all sampling years. From 1991-1993 (0.09; 0.14; 0.16) the claderan:copepod ratio was less than EA criteria (0.17; KNWR 1991); however, on average, the ratio showed no trend. Thus, current sockeye salmon fry stocking, levels do not appear to have changed the composition of cladacerans and copepods in Spiridon Lake.

Stocking, Smolt Emigrations and Biological Characteristics

Stocking and Smolt Production

Sockeye salmon stocking into Spiridon Lake has ranged from an initial experimental level of ~250,000 fry in 1990 to a high of 5.7 million fry in 1994 (Table 6). In 1991, stocking was increased over 10-fold from 1990 to 3.5 million fry and has averaged 4.2 million from 1991-1996. Fry stocked have ranged in size from a low of 0.18 g (1994) to a high of 1.4 g (1990). Since 1991, fry planted have averaged 0.25 g. Stocking size was above average in 1995 and 1996; 0.35 g and 0.30 g, respectively.

The initial production of smolt (1991 stocking year) from Spiridon Lake was predominantly (93%) age-1 fish (Table 6). Smolt migrations from fry stocked in 1992, however, were ~ 50% age-1 and 50% age-2 fish. Fish stocked in 1993, again, migrated primarily as age-1 smolt (73%). Fry to smolt survival (1991-1993) has averaged 28.8%. Survival to smolt was highest for fry stocked in 1991 at 45.3% and, appears lowest for fry stocked in 1994 at ~11%. The smolt migration is incomplete for fry stocked in 1994; however, few age-3 smolt are expected to migrate. Fry-to-smolt survival to date for juveniles stocked in 1995 is 17.5% which is similar to 1992 (20.8%) and 1993 (20.0%) fry.

Smolt Estimates, Mortality and Timing

Sockeye salmon smolts did not emigrate from Spiridon Lake during trapping (28 June to 23 July) in 1990 but a portion (~750) were captured in late May, early June in 1991. The total number of sockeye salmon smolt emigrating from Spiridon Lake were estimated annually from late April through late June (first week of July 1994 and 1996) from 1992 through 1996. The first sockeye salmon smolt emigrated from Spiridon Lake and past the barrier falls via the trapping (bypass) system and pipeline in 1992. That year, 1.5 million smolt were enumerated during the migration and represented the highest number of juveniles observed for all years (Table 7). The lowest smolt migration occurred in 1993 when 346,000 were estimated. In 1996, smolt migration was estimated at 1.1 million. Smolt mortality has been observed due to the high stream flows and large amount of hardware that smolt encounter as they pass through the bypass system. Mortality ranged from a low of 0.4% in 1994 to a high of 5.9% in 1992, averaging 3.2% for all smolt enumeration years (Table 7). Mortality has declined on average to 2.0% since 1993 as a result of hardware modifications and repositioning of the traps and weir .

Sockeye salmon smolt migrate from Spiridon Lake beginning in the first week of May, peaking in mid to late May (Figure 9). The migration declines by the first week of June, ending by late June. A small number of smolt may migrate into early July as was observed in 1994 and 1996.

Smolt Age and Size

Spiridon Lake sockeye salmon smolt were sampled from ~01 May through 30 June from 1992 - 1996. In 1991, smolt were sampled daily for age, length, and weight from mid May to mid June. Sample sizes ranged from a low of 596 smolt in 1991 to a high of 2,091 smolt in 1996 (Table 8) and generally varied with smolt abundance. Smolt were predominantly age-1 (>98%) in 1991 and 1992. The average age of smolt sampled was 69.3% age-1 and 30.4% age-2 for the remaining years (1993-1996). A small portion of age-3 smolt have been observed since 1993, comprising less than 1% of all smolt sampled. Average age-1 smolt sizes ranged from 9.2 g and 104 mm in 1995 to 19.3 g and 127 mm in 1991, while age-2 smolt averaged 20.7 g and 141 mm in 1996 and 58.9 g and 183 mm in 1992. Age-1 smolt were slightly larger in 1996 than those sampled in 1995; averaging 10.3 g and 109 mm. The general trend since fry stocking and smolt migrations began is a decline in smolt size for all age classes (Figure 10). The average size of age-1 smolt has exceeded the optimum size (5 g and 85 mm) stipulated as EA criteria (KNWR 1991) each year.

Spiridon Lake Resident Dolly Varden Char Trends

A variable mesh gill net was set in Spiridon Lake, once in May and again in June in 1991 and 1992, to capture adult Dolly Varden char for catch-per-unit-effort (CPUE) and size information. The gill net was set once in June and again in late August from 1993 to 1995. Gill netting effort focused at the mouths of South and West Creeks prior to 1993 and at West Creek only from 1993 through 1995 (Figure 5). Dolly Varden CPUE ranged from a low of 0.41 (South Creek) in 1991 to a high of 3.0 (West Creek) Dolly Varden per hour in 1992 (Table 9). West Creek average CPUE was 1.9 for all years; CPUE decreased slightly in 1994 to 1.2; however, increased again in 1995. Total catches of Dolly Varden ranged from 58 (1992) to 124 (1993), of which, the majority (57%) were 150 mm to 300 mm long (Table 10; Figure 11).

Beach seining for resident juvenile Dolly Varden in Spiridon Lake began in 1991. Beach seining efforts in 1991 occurred from 29 May to 24 June with a total of 28 sets made at East, West, and South Creek locations (Figure 5). The 1991 catch was 12 adult and 16 juvenile Dolly Varden (Table 11; Figure 12). Seining efforts focused on East and West creeks in 1991 and 1992, where catches of Dolly Varden were the highest. Fifty sets were attempted from 08-29 June 1992, capturing 278 adults and 84 young-of-the-year Dolly Varden. The number of sets (10-12) attempted declined from 1993-1995; however, seining locations remained the same. Seining efforts were spread out to two sets at each site in June and again in late August. Juvenile Dolly Varden catches decreased with the corresponding decrease in effort in 1993 to 1995 compared to the higher catches in 1991 and 1992. The change in catches did not necessarily indicate a decline in juvenile numbers since more sets were attempted in 1991 and 1992; efforts also concentrated in June, when young-of-the-year would be expected to enter the lake from creeks and provide a higher catch probability.

Commercial Fishery Evaluation

Commercial Fishing Activity in SBTHA

In 1994, the initial year of harvestable returns to SBTHA, there were permit holders fishing 37 days from 20 July through 17 September (Table 12). The number of fishers ranged from one on several dates in mid September to 34 observed on 14 August.

In 1995, the area encompassing the SBTHA was reduced (Figure 3). Also, the Northwest Kodiak District was open to fishing whereas the district was closed in 1994 for the majority of the season. As result, the commercial fishing activity declined in the SBTHA in 1995 when the peak number of fishers observed fishing on a single day was seven; however, there were 49 days from 20 July-11 September when at least one permit holder was observed fishing. The fishing activity was orderly without altercations between boats as had been observed in 1994. One notable observation occurred on 26 July 1995 when the F/V Too Late was documented fishing in closed waters in Spiridon Bay, approximately 0.8 km from the project site. The skipper of this vessel was later cited and prosecuted for the illegal activity as a result of ADF&G evidence collected at the time of the violation.

Fishing was observed on 44 days from 29 July-10 September in the SBTHA In 1996. The largest number of fishers observed was 32 on 29 July.

Escapement and Harvest Age Composition

Escapement samples, post 14 July, from local sockeye salmon stocks were assessed to determine contribution to the age 1.2 component of the catch (Nelson and Barrett 1994; Nelson and Swanton 1996c; Nelson and Swanton 1997). This assessment resulted in inclusion of Karluk late run, Ayakulik, Frazer, and Upper Station late run in 1994 and Ayakulik, Upper Station late run in the 1995 and 1996 analysis. Non-local stocks were considered improbable contributors in 1995 and 1996; however, Chignik late run and Upper Cook Inlet sockeye salmon were considered in 1994. The results of escapement sampling at these systems from 1994 - 1996 are described by Nelson and Barrett (1994), Nelson and Swanton (1996c), and Nelson and Swanton (1997), respectively.

The primary commercial harvest areas of interest for analysis of Spiridon Lake sockeye contribution were within the Northwest Kodiak District (Figure 4). Specifically, within the proximity of Uganik Bay, Uyak Bay, and SBTHA. A total of 2,582, 2,103, and 3,201 sockeye salmon were sampled from the catches in the Uganik area post 14 July in 1994-1996, respectively (Table 13; Appendix C). The predominant age classes represented included 1.2, 1.3, 2.2, 2.3, and

3.2 fish. Uyak area catch samples (n=3,069; 3,319; and 2,388, respectively) were comprised of five age classes (1.2, 1.3, 2.2, 2.3, and 3.2) during the post 14 July harvest, 1994-1996 (Table 14; Appendix D). The estimated age composition (n=1,329) of SBTHA sockeye salmon catches in 1994 was ~99% age 1.2 fish (Table 15; Appendix E). In 1995, age 1.2 (60%) were, again, the predominant age class; however, jack sockeye (age 1.1) comprised 20% of fish sampled (n=1,313) and a small number of age 2.2 (12%) and 1.3 (5%) were represented. Approximately 79% of the 1,875 sockeye salmon sampled in 1996 in the SBTHA were age 1.2 fish and 14.3% and 4.6% of fish sampled were age 2.2 and age 2.1, respectively. In addition to the Northwest Kodiak District, harvests from the Southwest Kodiak District and the Afognak District (southwest section) were sampled for age in 1996 to assist with the identification of Spiridon Lake sockeye. Results are reported by Nelson and Swanton (1997).

Northwest Kodiak District Harvest

The total estimated harvest, post- 05 July 1994, in the Northwest Kodiak District, was 622,658 sockeye salmon (Figure 13A and 14). Approximately 41% were caught in the Uyak area, 40% in the Uganik area, and 19% in the SBTHA. The Northwest Kodiak District harvest in 1995 (post-14 July) was estimated to be 533,253 sockeye salmon, of which 58% were caught in the Uyak area, 37% in the Uganik area and just 6% within the SBTHA (Figure 13B and 14). The 1996 sockeye salmon harvest (post-14 July) within the Northwest Kodiak District was estimated at 680,251 fish (Figure 13C and 14). Uganik area harvest comprised 48% of the total, Uyak area 28%, and the SBTHA 24%.

Proportion of Spiridon Lake Sockeye Salmon in the Northwest District Harvest

The estimated proportion of Spiridon Lake sockeye salmon of all age classes combined was 27.1% (68,325) in Uganik Bay catches, 30.6% (77,774) in Uyak Bay catches, and 99.8% (115,609) in SBTHA catches in 1994 (Barrett and Nelson 1994; Appendix F). The proportion of Spiridon Lake fish in the Northwest District sockeye harvest in 1994 was 42% (261,678). Only 1.2% of the Southwest District's sockeye catch were Spiridon Lake fish. If considering only the predominant age classes (1.1 and 1.2) of Spiridon returns, 77.4% (35,209) of the Uganik Bay catch, 70.0% (29,804) of the Uyak Bay catch, and ~100% of the SBTHA catch were considered of Spiridon Lake origin in 1995 (Nelson and Swanton 1996c; Appendix G.1 and G.2). Harvest data for 1996 indicate that 46.7% (153,292) of Uganik Bay catches, 33.0% (62,670) of Uyak Bay catches, and ~100% (162,118) of SBTHA catches were of Spiridon Lake origin as reflected by scale patterns (Appendix G.3). The final apportionment of the Spiridon Lake sockeye contribution are reported by Nelson and Swanton (1997).

Estimated Harvest of Spiridon Lake Sockeye Salmon

The estimated harvest of Spiridon Lake sockeye salmon in 1994 was ~264,000 of which 262,000 (99.2%) were caught in the Northwest Kodiak District and the remainder (0.8%) harvested in the Southwest Kodiak District (Barrett and Nelson 1994; Appendix F). That year, within the Northwest Kodiak District, the largest harvest of Spiridon sockeye salmon was in the SBTHA (44%), followed by Uyak Bay (30%), and Uganik Bay (26%; Table 16; Figure 14). The Spiridon Lake sockeye salmon harvest contribution in 1995 was estimated at ~97,000 fish; all caught within the Northwest Kodiak District, of which 36% were harvested in Uganik Bay, 31% in Uyak Bay, and 33% in the SBTHA (Nelson and Swanton 1996c; Appendix G.2). Approximately, 387,000 Spiridon Lake sockeye salmon were harvested in 1996 (Nelson and Swanton 1997). The majority of the catch (378,080; 98%) occurred in the Northwest Kodiak District (Appendix G.3); the remainder (8,876; 2%) were harvested in the Afognak District (southwest section). Approximately 40% were harvested in the Uganik Bay area, 16% in Uyak Bay, and 42% in the SBTHA. Total sockeye harvests and the harvest of Spiridon Lake sockeye in Uganik, and Uyak Bays exhibited similar patterns in 1994 and 1996. That is, the relative harvest rate of Spiridon Lake sockeye corresponded to the relative overall sockeye harvest rate for each area (Figure 14). This pattern was not evident in 1995 when the harvest of Spiridon Lake sockeye was greater in Uganik Bay, while the overall sockeye harvest was greater in Uyak Bay.

Uganik Bay and Uyak Bay Landing Trends

The average number of salmon landings by gear type (gillnet and purse seine) from 1994-1996 has increased for most statistical weeks when compared to 1970-1993 for both the Uganik and Uyak areas (Figure 15; Appendix H). Exceptions to this trend occurred in the Uganik area where the average declined from 1994-1996 for purse seine landings and also to a lessor degree for gillnet landings for all statistical weeks, aside from those in late August (22 August) and September, which increased. Landings were less from 1994-1996 than 1970-1993 for the week ending 18 July for both areas and gear types.

Sockeye landings show similar trends for both Uganik and Uyak areas; substantial increases occurred in late August (weeks ending 22 and 29 August) for both gear types (Figure 16; Appendix H).

Spiridon Lake Sockeye Salmon Harvest Timing

The majority of Spiridon Lake sockeye salmon were harvested from 08-29 August in 1994 (Figure 17A). In Uganik Bay and Uyak Bay, peak harvests occurred during the week ending 29 August. The largest catches in the SBTHA (Telrod Cove) occurred during the week of 15 August when the other fishing areas were closed. In 1995, Spiridon Lake sockeye salmon were harvested earlier than in 1994, with peak catches occurring from the weeks of 25 July-08 August (Figure 17B). The peak harvests in Uganik Bay and SBTHA were again during the weeks of 29 August and 15 August, respectively, in 1995. Uyak Bay harvests peaked from late July to 08 August. The 1996 harvest of Spiridon Lake sockeye salmon peaked during the weeks of 08 August in Uganik Bay, 22 August in Uyak Bay, and 15 August in the SBTHA (Figure 17C). Large harvests occurred throughout August in the SBTHA as well as Uyak Bay. Spiridon Lake fish continued to be caught in Uyak Bay until mid-September.

Sockeye salmon returning to Spiridon Lake from 1994-1996 had run timing similar to the brood source as reflected by escapement timing of late run Upper Station sockeye salmon (Figure 17).

The distribution and magnitude of sockeye salmon harvests and landings, as well as harvest (run) timing as described above, are likely influenced by the timing of the KMA salmon fisheries. For example, fishery closures occurred in Uganik, Uyak, and Spiridon Bays in early and mid August in 1994 due to depressed pink salmon runs. As a result, more sockeye were caught in the SBTHA that year than the other areas (Figure 14). Conversely, when pink salmon runs were at record levels in 1995 the entire Northwest Kodiak District was open to commercial fishing from late July through August. Consequently, more Spiridon Lake sockeye were harvested in the Uganik area than the SBTHA in 1995; harvest in Uyak Bay that year was similar to that in the SBTHA. The 1996 salmon season was again impacted by low pink abundance and resulted in closures in some fishing areas. Uyak Bay was closed from late July through September, but Uganik Bay was open for periods in late July and August. Thus, harvest of Spiridon bound sockeye increased proportionately in Uganik Bay while declining in Uyak Bay in 1996. Refer to Appendix I for an overview of the 1994-1996 KMA commercial salmon season fishery by district and section and for further detailed information (Brennan et al. 1996; 1997; *in press*).

Return by Stocking Year and Survival

Approximately 276,000 adults returned as result of fry stocked in 1991 (brood year 1990). Smolt-to-adult survival was estimated at 17.4%; overall survival (fry-to-adult) was estimated to be 7.9% (Table 17). The adult returns are incomplete for the remaining stocking years; however, 131,000 and 340,000 sockeye have returned thus far for fry stocked in 1992 and 1993, respectively. The magnitude of these returns indicates exceptional marine survival (~29%-40%) for three, four and five year old fish (ages 1.1,1.2,1.3,2.1, and 2.2).

Incidental Salmon Harvest in the SBTHA

The incidental harvest of pink salmon in the SBTHA was estimated to be 30,337 in 1994, 100,426 in 1995, and 42,705 in 1996 (Table 18 and 19). Chum salmon incidental harvest estimates were 297, 8,474, and 2,688 fish, respectively, from 1994-1996. Lastly, approximately 2,590, 139, and 1,626 coho salmon were harvested from 1994-1996, respectively in the SBTHA.

The peak harvest of pink salmon occurred during the week ending 15 August in 1994, the week ending 22 August in 1995, and the week ending 01 August in 1996 (Table 19). Large pink salmon harvests also occurred during the weeks ending 15 August in 1995 and the weeks ending 08 and 15 August in 1996. Chum salmon peak harvests occurred during the week ending 15 August in 1994, during the week ending 08 August in 1995, and during the week ending 01 August in 1996. The magnitude of chum salmon caught was similar to the peak for the week ending 08 August in 1996. The majority of coho salmon were harvested during the weeks ending 05 September, 22 August, and 29 August for 1994-1996, respectively.

Spiridon River and Spiridon Bay Monitoring

Index Escapement Estimates

ADF&G was required to monitor index escapements to Spiridon River (stream number 254-401) during years returns occurred at Spiridon Bay and SBTHA as part of the Spiridon Lake Project EA criteria (KNWR 1991). The minimum and targeted (desired) escapement ranges for Spiridon River are 15,000 to 45,000 pink salmon, 15,000 to 45,000 chum salmon, and 4,000 to 12,000 coho salmon (Malloy and Prokopowich 1992; Brennan et al. 1996). The average index escapement from 1968 to 1990 for pink, chum, and coho salmon for Spiridon River was 24,000, 17,240, and 9,105, respectively (KNWR 1991).

The ADF&G and FWS conducted nine salmon aerial escapement surveys of Spiridon River in 1994, eight surveys in 1995, and six in 1996 (Appendix J). The intent was to increase surveys in 1995 and 1996; however, due to poor visibility as result of weather conditions, the number of surveys decreased. In 1994, surveys resulted in an index escapement estimate of 12,800 pink salmon, 10,300 chum salmon, and 4,800 coho salmon (Table 18). Index escapement estimates increased in 1995 to 69,800 pink salmon, 22,000 chum salmon, and 10,300 coho salmon (the SBTHA was reduced in 1995). In 1996, pink salmon index escapement of 5,700 was the lowest observed since 1984 (4,000); chum salmon index escapement of 8,000, the fifth lowest in the last 17 years; and coho index escapement of 10,600 the third highest in the last 15 years (Table 18). Pink salmon and chum salmon minimum escapement goals were not met in 1994 and 1996; but minimum goals were achieved for chum salmon and targeted goals were met for pink salmon in 1995. Coho salmon minimum escapement goals were met in all three years (1994-1996). The average index escapement for pink salmon, chum salmon and coho salmon for Spiridon River from 1980-1996 was 33,269, 22,390, and 7,520, respectively.

Telrod Creek index escapements estimates for pink salmon were made by aerial survey except for 1993-1996 when foot surveys were conducted (Table 18). Foot surveys were primarily designed to estimate sockeye salmon escapement as result of returns from the Spiridon Lake stocking project. Pink salmon escapement has ranged from a low of 20 (1983) to a high of 5,000 (1993), averaging 188 fish since 1980. The pink salmon escapement goal for the system is 100 fish (KNWR 1991). In 1995 and 1996, pink salmon escapement was achieved (233 and 238, respectively) by manually releasing fish over the barrier net deployed to prevent sockeye salmon from escaping the commercial fishery into Telrod Creek. The use of the barrier net has effectively prevented sockeye salmon escapement into the creek. Sockeye salmon escapement was 3,500 fish (1993 and 1994) prior to use of the barrier net compared to just 10 and 12 fish observed in 1995 and 1996, respectively. In addition, the barrier net has not resulted in any negative impacts to wildlife or any increase in wildlife activity (S.Schrof, ADF&G, Kodiak, personal communication).

Spiridon Bay Wildlife Surveys

A total of 18 wildlife surveys were conducted in Spiridon Bay from 1991 - 1996 (Appendix K). An average of three surveys were completed each year. The results of surveys were compiled by FWS personnel and data are not presently available for inclusion in this document.

Brood Stock Evaluation: Saltery Lake Sockeye

Disease Incidence: Spiridon River Stocks

Thirty-nine chum salmon were sampled for IHNV on 22 August 1995. The virus was not detected in any of the ovarian fluid samples (Table 20). Historically, IHNV has not been detected in any chum salmon stocks screened from systems in the Kodiak area (Table 20). In addition, in the State of Alaska, only five of 18 wild chum salmon stocks sampled have resulted in detection of IHNV (Appendix L). Of these, the incidence of IHN virus averaged <10%. Spiridon River sockeye salmon and rainbow trout were not sampled for IHNV.

Genetic Characteristics: Upper Station and Saltery Lakes Sockeye Salmon

Genetic samples from 200 Upper Station Lake (100 from each lake) late run sockeye salmon were collected in September 1993 and from 100 Saltery Lake sockeye salmon in September 1994. Sockeye salmon from Spiridon River were not sampled for genetics in 1995 or 1996.

The sockeye salmon sampled from lower and upper Upper Station Lakes and Saltery Lake were distinctly different based on preliminary allele frequency analysis (Table 21) and G-statistics (C. Habicht, ADF&G, Anchorage, personal communication; Table 22). As expected, the collections from Upper Station (lower and upper lakes) were more similar to each other than to Saltery Lake sockeye (Figure 18). H-W analysis did not detect mixed stocks at any of the three collection sites (Table 23).

Saltery Lake Sockeye Salmon Run Size, Escapement, and Timing

Saltery Lake is the largest sockeye salmon producer on Kodiak's eastside (ADF&G 1994). The Saltery Lake sockeye escapement goal is 20 to 40 thousand fish, and the average run potential is estimated to be 100 thousand fish (Barrett and Nelson 1994; Brennan et al. 1996). The mean escapement from 1987-1996 was 37,800, ranging from a low of 22,705 (1987) to a high of 77,200 (1993) fish (Table 24). The escapement goal was exceeded each year from 1991-1996 (Brodie 1996).

About 90% of the Saltery escapement occurs from late June through mid August (Barrett and Nelson 1994; ADF&G 1994). The midpoint of the escapement averages 18 July (Figure 19).

Saltery Lake sockeye salmon escapement may not be a true indicator of run timing because of variation in harvest rates (ADF&G 1994). Antidotal information suggests that the commercial fishery influence is stronger on the later half of the run than on the earlier half. The bias in using the escapement count as a gauge of run timing is estimated to be one week. Accordingly, the estimated actual run timing of the Spiridon Lake run using the Saltery brood stock is from about 03 July to 08 August on Kodiak's westside (Appendix M). At Telrod Cove, the timing should be similar (04 July- 09 August) beginning and ending about two to three weeks earlier than the Upper Station late run (Figure 19).

Escapement tagging and survey results in 1994 indicate that there is no time-of-entry difference between Saltery Lake shoal and tributary stream spawners (Table 25). Thus, if eggs from Saltery Lake sockeye are collected approximately proportional to the escapement (similarly to 1994 brood collection), they would be assumed to represent the population with respect to timing, age, and other genetic characteristics and would minimize sub-stock-specific impacts.

Saltery Lake Sockeye Salmon Escapement Age Composition

Escapement age samples indicate that the Saltery sockeye run is primarily comprised of fish having spent three winters in the ocean as adults (ADF&G 1994; Table 26). The dominant ages are 1.3 and 2.3 fish which, combined, average about 75% annually. Two ocean age fish (ages 2.2 and 1.2) average about 21%. The Upper Station late run brood stock averages about 79% two-ocean age fish and 21% three-ocean age fish (ADF&G 1994).

Saltery Lake Sockeye Salmon Disease Incidence

Saltery Lake sockeye salmon, as with all anadromous sockeye salmon examined in Alaska, have been found to be a carrier of infectious hematopoietic necrosis virus IHNV (ADF&G 1994; Ted Meyers, ADF&G, Juneau, personal communication). Ovarian samples collected from Saltery Creek sockeye salmon spawners in 1986 and 1994-1996 revealed that IHNV incidence is cyclic (Table 27). Samples indicated the lowest incidence (33%) was in 1995, while in 1994 incidence was the highest (92%). Upper Station (as well as Little Kitoi Lake) sockeye salmon have also showed variability in the incidence of IHNV (Table 27). For example, in 1987, incidence was 21%, while in 1989 incidence was 73%. Afognak and Malina Lakes are the only sockeye stocks used for brood sources for area stocking projects that exhibited a low IHNV incidence.

DISCUSSION

Lake Habitat Impacts

The general water chemistry parameters measured in Spiridon Lake have not varied much in mean concentration throughout the years sampled. However, on some dates the concentrations substantially differed from the means as indicated by the high standard deviation, such as that found for iron. This is most likely due to natural conditions in the lake, but also could be due to sample contamination (G.Kyle, ADF&G, Soldotna, personal communication). Regardless, the seasonal means for these parameters are within ranges found for oligotrophic lakes.

Nutrient concentrations in Spiridon Lake, although inherently low, have remained quite stable throughout the years sampled. Barren lakes do not receive allochthonous inputs from salmon carcasses as do lakes with self sustaining runs. The mean concentrations of inorganic (reactive) P and all nitrogen fractions (Kjeldahl, ammonia, and nitrate-nitrite) in Spiridon Lake, however, were typical of oligotrophic lakes and exhibited little variability. Algal biomass (chlorophyll *a*) concentrations are also, typically, less (~by a factor of two) in barren lakes than those with established sockeye runs and is likely a result of increased grazing by unchecked zooplankton populations (Kyle 1996). Chlorophyll *a* concentrations in Spiridon Lake showed no trends. Relative higher mean concentrations occurred in 1993 and 1995, which reflects a higher allochthonous (watershed) input of nutrients or a lower cropping by zooplankton.

The 1996 TN:TP ratio (230:1) indicates no trends other than that Spiridon Lake continues to be phosphorus limited as was first reported (198:1) prior to sockeye stocking (Kyle et al. 1990).

Barren lakes typically have lower total phosphorous concentrations (~2 $ug \cdot l^{-1}$) than oligotrophic lakes that have sockeye salmon runs (Kyle 1996). Sockeye smolt emigrating from a lake usually comprise less than 10% of the phosphorus budget (G.Kyle, ADF&G, Soldotna, personal communication); thus, it is presumed that fry stocking has not effected the TN:TP ratio.

Prior to stocking, Spiridon Lake maintained a relatively robust standing crop of zooplankton (Kyle et al. 1990); and, as with many other barren systems evaluated and compared to lakes with established runs of sockeye, indicated introduced planktivores such as sockeye fry could be supported (Kyle 1996). Other barren systems stocked with sockeye fry have exhibited a variation in response by the zooplankton community (Kyle 1996). The seasonal mean zooplankton density in Spiridon Lake, although showing variability, has not indicated a definitive trend associated with the initiation of stocking in 1990. Similarly, the seasonal mean zooplankton biomass showed no trend associated with stocking. Zooplankton biomass declined the first three years (1991-1993) after stocking at conservative levels, but has gradually increased the last three years when the stocking level increased (4.6 to 5.7 million sockeye fry). This pattern is not unusual since zooplankton populations often rebound quickly after initial high mortality occurs (Gliwicz et al. 1981); an effect of a higher food (phytoplankton) level due to decreased density (Kyle 1996). The increasing and decreasing densities of *Cyclops* and *Diaptomus*, respectively, has been noticeable; however, copepods often undergo cycles of abundance (G.Kyle, ADF&G, Soldotna, personal communication). These cycles are frequently due to factors other than predation such as environmental variability, and intercompetition for habitat. Moreover, the average size of these species have remained stable and they continue to be relatively large, indicating that size-selective predation that often occurs in sockeye salmon nursery lakes is not evident in Spiridon Lake (G.Kyle, ADF&G, Soldotna, personal communication).

Based on the criteria for limnological parameters in the environmental assessment (EA), most of the above data were within the EA constraints. One exception is that the EA lists a cladoceran to copepod ratio not to exceed 0.17:1; however, in 1994 and 1995 this ratio was 0.30 and 0.35, respectively. Such changes in the zooplankton community may result from the affect of vertebrate planktivores (e.g. juvenile sockeye salmon; Stenson 1972, 1976; Kerfoot 1980; Vanni 1986; Kyle et al. 1988; Edmundson et al., 1993; Koenings and Kyle 1996; Kyle 1996). Copepods are often the predominant species of macrozooplankton in barren lakes since they are more efficient feeders than cladocerans (Kyle 1996). Spiridon Lake is no exception; the composition of the macrozooplankton population is dominated (85%) by copepods. Even though copepods have adapted to cold environments by devoting much of their energy intake into lipid reserves, their mode of reproduction is considered detrimental to the annual production potential of lakes (Kyle et al. 1990). Unlike cladocerans, copepods regenerate slower, as result of reproducing sexually, and have a delayed response to changes in lake productivity and/or abundance of predators. Heavy predation on copepods can lead to a drastic reduction in the recruitment of nauplii. In addition, copepods are more conspicuous to visual predators because of their size and visible egg clusters; however, they can avoid predators due to their physiological agility. Thus, Spiridon Lake's juvenile sockeye salmon rearing capacity is dependent upon balancing introduced numbers of fry with a zooplankton community that is relatively sensitive to predation. Cladocerans are good indicators of the effect of predation because they are usually first to be impacted when fish are introduced to a lake (Kyle 1996). The increase in the 1994 and 1995 cladoceran composition (higher ratios) was similar to the composition found in 1987 and

1988. This suggests increased allochthonous fertility since cladocerans respond quickly to changes in lake productivity. Also, the higher percentage of cladocerans occurring when the stocking level was relatively high in 1994 and 1995, indicates the lack of excessive foraging by fry as cladocerans are preferred (over copepods) as a food item (Drenner et al. 1978; Wright and O'Brien 1984 *in* Kyle 1996). Thus, the variation in the composition of cladocerans and copepods is probably not related to the initiation (and extent) of fry stocking into Spiridon Lake.

Stocking Strategies: Effects on Lake Habitat, Production, and Run Reconstruction

The initial recommendations for stocking density (Kyle et al. 1990) were changed (reduced) to a more conservative approach based on the results of other Alaska barren lake stocking projects. The stocking of salmon fry in barren Alaska lakes revealed varied responses by the macrozooplankton community (Kyle 1996). Factors that may influence the success of fry plants include lake morphology, zooplankton diversity and abundance and ability to adapt to predation influences. The limnology data collected from Spiridon Lake indicate the current stocking rates have resulted in stable responses by the macrozooplankton community as well as the nutrient base and algal community. Spiridon Lake has had a consistent zooplankton density (and consistent zooplankton community) for the last four years when the stocking level ranged from 4.2 to 5.7 million; thus, the lake may be able to support a larger number of stocked fry.

The original stocking goal (11 million) was estimated by way of an average model for lakes with pre-existing sockeye populations (Koenings and Burkett 1987). This approach to setting a long term stocking goal is predicated upon annual evaluation of the zooplankton community. Barren lake sockeye salmon stocking is still in the experimental phase (Kyle 1996) of which Spiridon Lake is no exception. The first phase of the incremental stocking plan is just now being implemented. Thus, the long term stocking plan for the lake should be re-evaluated as more data are available. The short-term strategy (5 year plan) will need to be flexible and conservative; determined on an annual basis.

The application of a range of data or a threshold value may be more appropriate for long term management of the project rather than the present EA criteria. The current limnology criteria are based on averaging of historical data and may not adequately account for natural variation or be indicative of biological thresholds. For example, *Bosmina* size criteria for the project is >0.55 mm (KNWR 1991); however, a *Bosmina* length of 0.40 is acceptable based on observed positive electivity by sockeye salmon. *Bosmina* below a 0.40 mm are indicative of intense predation (Koenings and McDaniel 1983; Kyle et al. 1988). Thus, *Bosmina* of <0.55 mm are adequate size for sockeye to positively select. The most important criteria should be a threshold value or range (i.e. percent change) in zooplankton density, size, and biomass (G.Kyle, ADF&G, Soldotna, personal communication). If this threshold is exceeded, then action would be taken to correct the trend such as a change in stocking level or stocking strategy (life stage). Nutrient concentrations, ratios, or chlorophyll concentrations are not as critical; however, these and the other EA criteria (smolt size, incidental harvest of Spiridon River salmon) should also be modified in this manner.

A component of zero-age (underyearlings) sockeye smolt emigrate annually from Upper Station Lake (Barrett et al. 1993). Sockeye salmon smolts did not emigrate from Spiridon Lake during trapping (28 June to 23 July) in 1990, indicating that stocked sockeye salmon fry did not gain the growth or undergo the physiological changes necessary to migrate as underyearlings and tolerate seawater (Kyle et al. 1990). Other studies of underyearling smolts indicate that the fish need to reach approximately 50 mm in length and 1.5 g in weight to tolerate seawater (Wood et al. 1987; Rice and Moles 1988; Murphy et al. 1988; Hiefitz et al. 1989). The production of age-0 smolts in Upper Station Lake is likely an environmental consequence rather than a genetic trait achieved by rapid growth in the May-July period due to warm lake temperatures (> 10^0C) and high lake productivity (Kyle et al. 1990). The production of age-0 smolts in Spiridon Lake has not occurred, likely due to much cooler water temperatures (< 10^0C) during May through early July. The result of this initial stocking alleviated the concern that the smolts would migrate as under-size (due to slower growth) age-0 fish due to a genetic attribute.

Fry-to-smolt survival has varied each year. The poorest survival (~11%; 1993) occurred when the fry stocked were the smallest (0.18 g). Survival has been as high as 45%, averaging ~20% when fry were larger (0.25 g). This is not unexpected, as larger fry have a competitive advantage compared to smaller fry. In addition, the larger fry are stocked later (mid-June), and likely benefit from the lake warming and providing more forage (zooplankton blooms). This supposition would indicate that the release of larger fry at later dates would increase survival; however, if too many large of juveniles (fingerlings) were released, the potential for deleterious effects on the zooplankton community may increase as result of the unstable nature of a barren-type lake such as Spiridon (Kyle 1996). Therefore, the potential instability of the zooplankton community in this barren lake warrants a more conservative approach to fry stocking.

The rearing of sockeye salmon juveniles to late fall (October) and stocking in barren lakes just prior to freeze-up is an enhancement strategy that has been used in the Prince William Sound (PWS) area, as well as on Kodiak Island (Honnold et al. 1996). This strategy takes advantage of the cool lake temperatures, and thus, the declining basal metabolism of the sockeye juveniles (presmolt). That is, presmolt released in late fall will not actively feed because of the low temperature units (TU); thus, will not over-graze on the declining seasonal abundance of zooplankton. Moreover, presmolt "hold-over" in the lake will be minimal with the majority migrating the following spring prior to actively feeding on the zooplankton population. This sequence of events has been observed at Little Kitoi Lake where presmolt are stocked each fall and migrate (>90%) the following spring with little impact on the zooplankton population (Honnold et al. *in press*; Hall et al. 1997). Aside from the minimal impact on the zooplankton community, the increased size at release (~5-10 g) will likely result in increased survival. In PWS, presmolt to smolt survival has been as high as 60% (Edmundson et al. 1993). Preliminary results of presmolt stocking projects on Kodiak Island have produced similar survival rates and also have provided stable or increasing zooplankton abundance and biomass for most lakes (Honnold et al. *in press*). This stocking strategy may be a feasible alternative or addition to the current approach used for the Spiridon Lake enhancement project and should be considered in the future.

Smolt age and size at migration from Spiridon Lake indicates that fry stocking levels are less than the theoretical optimum. Smolt sizes are gradually declining, on average; however, age-1 smolt in 1996 were over 20% larger (length) and 50% more robust (weight) than the theoretical optimum size (85 mm; 5.0 g) suggested by Koenings and Burkett (1987). This would suggest that additional juveniles may better utilize the lakes forage base, would eventually result in smolt sizes (density effect) closer to the theoretical optimum, and would maintain a high marine survival (at or above 20%). This supposition, however, does not account for the potential inconsistent response of the macrozooplankton community in the lake as documented at other barren lakes (Kyle 1996) or the potential impacts to run reconstruction if the distinct freshwater scale pattern (Nelson and Barrett 1994; Nelson and Swanton 1996c; Nelson and Swanton 1997) is affected by the reduced smolt size. Again, a gradual approach to increasing fry stocking should be implemented due to the above considerations.

Resident Fish Impacts

Spiridon Lake Dolly Varden char CPUE and size sampling did not indicate any trends. The FWS recommended that sampling be discontinued in 1996.

Harvest Impacts

The Northwest Kodiak District was intended to be the primary harvest area for Spiridon Lake (Telrod Cove) - bound sockeye, with the SBTHA as the secondary harvest site. Harvest data from pertinent statistical areas, collected by ADF&G fish tickets and field personnel, in conjunction with escapement data from the Spiridon Bay systems, collected by aerial surveys, are used to identify project impacts.

Escapement surveys of Spiridon Bay systems have increased since the inception of the Spiridon Lake project. Escapement indices, as a result of these surveys, are considered conservative; water visibility is often poor or less than optimum due to glacial run-off into Spiridon River (D. Prokopowich, ADF&G, Kodiak, personal communication). Aerial survey coverage was fair in 1994, but declined in 1995 and 1996 as result of weather and manpower constraints. Escapement indices for 1994 suggest that both Spiridon River pink and chum salmon minimum escapement goals may not have been met; whereas, minimums were exceeded for each species in 1995. Escapements may have been less than the minimum goals in 1996 for both species. Coho escapement in 1994 appeared adequate and was exceptional in both 1995 and 1996.

The Spiridon Bay Management Plan was approved by the Board of Fisheries in 1993 (ADF&G 1994). This plan provided a frame-work for conducting a directed harvest on Spiridon Lake-bound sockeye salmon inside the normal regulatory closed waters of Spiridon Bay (Figure 2). The plan, as written, was first implemented in 1994 when the first Spiridon Lake returns occurred; thereafter, prior to the 1995 and 1996 fishing seasons, was modified by ADF&G Emergency Order to improve protection to Spiridon Bay wild stocks. Specifically, the SBTHA was reduced to Telrod Cove proper (Figure 3) and fishing time increased to maximize the harvest of enhanced Spiridon Lake sockeye.

Approximately 5% of the pink salmon harvested from statistical areas 254-40 and 25-450 (total combined harvests for Spiridon Bay and SBTHA) were caught in the modified SBTHA in 1995, compared to ~8% in 1994. Chum salmon harvest in the SBTHA comprised ~1% and ~9% of the combined chum salmon harvest in 1994 and 1995, respectively. Both chum and pink salmon abundance in 1995 were much larger as reflected by escapement goals being met as well as large increases in harvests. The proportion of chum and pink salmon harvested in the SBTHA increased to 16% and 33%, respectively in 1996, when the abundance (run strength) of pink and chum salmon declined. Escapement likely would have still remained less than the minimum goal even if all chum salmon caught in the SBTHA were destined for Spiridon River. Pink salmon minimum escapement goals were met in nearby systems (D.Prokopowich, ADF&G, Kodiak, personal communication) which may indicate that aerial survey counts at Spiridon River were biased low.

The selection of a late run sockeye stock (Upper Station) for the Spiridon Lake project was intended to provide peak run timing allowing maximum harvest opportunity during traditional fisheries for westside late chum, pink and coho salmon (Kyle et al. 1990). It was anticipated that a large portion of enhanced sockeye salmon would be harvested in the Northwest Kodiak District during openings directed for the harvest of Karluk Lake sockeye salmon and westside pink and chum stocks. Thus, the incidental harvest of natural stocks during the 1994-1996 fishery at SBTHA and Spiridon Bay was anticipated. The reduction of the SBTHA in 1995 was intended to reduce the incidental harvest of Spiridon River bound salmon stocks and also provide for a more orderly fishery. The Spiridon Lake project is evolving and, certainly, the magnitude of returns each year effects the incidental harvest rate. At this time, it is difficult to assess the present management strategy employed for harvest of Spiridon Lake bound sockeye salmon. Run strength has varied considerably for the two years of a reduced terminal harvest area and only one pink salmon cycle (even-odd) has been observed. Thus, it is prudent to continue the current management strategy of employing continuous openings once a build up of sockeye salmon occurs in the SBTHA and to continue monitoring the incidental harvest trends. In addition, Spiridon River index escapement estimates should be further refined with more aggressive aerial surveys conducted. The feasibility of using index areas in the system should be explored to provide consistent data collection. This may include comparison of abundance in defined areas off the mouth of Spiridon River and within the stream (including tributaries) to overall stream estimates for historical and in season data. The relationship between specific survey area data and overall stream escapement data may indicate potential areas for escapement indexing. Modification of management strategies should be considered if escapement estimates based upon improved indexing continue to be less than minimum goals for pink and chum salmon.

Finally, the terminal harvest area may require adjustment (in an attempt to further restrict the catch to only Spiridon Lake sockeye salmon) or the fishery may need to be limited in duration if it appears that other salmon-producing systems in the area are not receiving adequate escapements solely as result of this project (D.Prokopowich, ADF&G, Kodiak, personal communication).

The scale pattern of Spiridon Lake sockeye salmon has remained consistent and readily distinguishable from other local and non-local stocks and enables the harvest of Spiridon Lake sockeye to be identifiable by geographic location (Nelson and Barrett 1994; Nelson and Swanton 1996c; Nelson and Swanton 1997). Run reconstruction estimates may be conservative since they are primarily based only on the identification and age composition of age 1.2 and 1.1 fish (P. Nelson, ADF&G, Kodiak, personal communication).

In virtually all statistical weeks the average number of landings has increased when compared to 1970-1993 for both the Uganik and Uyak areas. The sockeye landings show the same trend of increased landings. In both cases this is likely an artifact of large sockeye and pink salmon runs that have prompted generous fishing time versus earlier years when run strength was weak (C.Hicks, ADF&G, Kodiak, personal communication). In addition, as quality control has become a more substantial issue, the number of landings could potentially increase due to more fish tickets being processed. However, it should be noted that when comparing a 23 year data set average with a 3 year average, one must consider the overall pattern and refrain from over analyzing specific dates or landing numbers. Furthermore, an increase in the average number of landings does not necessarily mean an increase in the average number of fish caught.

In most cases there is little difference between all species and sockeye only landings. Thus, given the existing Northwest Kodiak District management plan (Prokopowich et al. 1996; Brennan et al. *in press*), even marked increases in sockeye production from the Spiridon enhancement project should not have any affect upon existing management scenarios other than in the SBTHA.

The run timing of Spiridon Lake sockeye salmon has remained consistent and continues to parallel that of the broodstock used for the project. The length of marine residence may be influenced by genetic factors since the majority of adults have returned as 2-ocean fish which is also the trend of late run Upper Station sockeye salmon (ADF&G 1994). Study of Wood River sockeye stocks indicate that ocean age was most often determined by the ocean age of the parents (genetic inheritance) (Rogers 1987). Previous studies support these findings (Godfrey 1958; Ricker 1972) but others have contended that environmental factors which determine freshwater (Peterman 1982; Hyatt and Stockner 1985; Rogers 1987) and ocean (Krogias 1960; Bilton 1970) growth, determine ocean age of returns. Also, the parental age and associated size of female spawners has been suggested to influence the age at maturity (ocean residence) of sockeye salmon (Bilton 1970, 1971; Bradford and Peterman 1987). The returning adults in 1998 and 1999 (two and three ocean age) are expected to be comprised largely of Saltery Lake stock. Saltery Lake sockeye salmon, on average, return after three years marine residence (ADF&G 1994). Therefore, if genetically programmed, larger returns of Saltery stock sockeye may occur in 1999. However, if age 1.2 adults are predominant, resulting in larger returns in 1998, then environmental influences rather than genetic inheritance may determine ocean age of Spiridon Lake sockeye.

Freshwater age of Spiridon Lake sockeye appears strongly influenced by environmental factors (abundant food and minimal competition) which enable substantial growth in only one year of rearing. Fast growing fish tend to smoltify at an earlier age; however, seaward migration obviously has a racial or genetic component apparently related to historical conditions for success in the nursery lake and the ocean (Burgner 1987). Karluk and Frazer Lake sockeye smolt, for example, typically migrate after two to three years of freshwater residence even though they grow fast in their first year of lake rearing (Barnaby 1944; Drucker 1970; Koenings et al. 1984; Kyle et al. 1988; Swanton et al. 1996). Brood fish (BR 1990) used for 1991 fry stocking were 56% freshwater age-1, while smolt emigrating in 1992 were 99% age-1. Brood fish in 1991 were predominantly freshwater age-2 (71%) compared to the resultant smolt which were largely age-1 (67%). Similarly, in 1994 migrant smolt were 74% age-1 but were produced from brood fish (BR 1992) that were 58% freshwater age-2. Initial data indicate that environmental factors are the primary influence upon freshwater age at smolting in Spiridon Lake. The freshwater age of brood stock should be monitored each year to compare parental versus offspring freshwater age to further refine this observation.

Adult Disease Transmission Risks

The sampling for IHNV incidence in chum and sockeye salmon from Spiridon River has been problematic. In 1995 and 1996, stream conditions, visibility, and poor flying conditions prevented the desired samples to be collected. The likelihood that IHNV will be detected in Spiridon River chum salmon is remote as indicated by initial samples (0% incidence). In Alaska, IHNV is rarely found in adult chum salmon and was only first reported in adults in 1985 (Follet et al. 1987). Since then, of 21 chum salmon stocks sampled in Alaska, only five have been detected to carrier IHNV (Appendix L). Of the wild chum salmon stocks sampled, most occur in the same drainages that sockeye salmon reside and spawn. The prevalence of infection with IHNV is high for sockeye salmon based on routine diagnostic screening of all stocks used or proposed for use in enhancement activities since 1974; it is widely assumed that all wild Alaskan sockeye salmon stocks are carriers of the virus (Meyers et al. 1990). Moreover, horizontal transmission often occurs in sockeye salmon stocks; however, chum salmon have been considered to be more refractory to infection by IHNV than sockeye salmon (Follett et al. 1987). Collecting IHNV samples from Spiridon River sockeye salmon does not appear feasible if escapements remain low (~400 in 1995 and ~100 in 1996).

Adult Straying Risks: Genetic Classification of Brood Sources and Wild Stocks

Genetic sampling of sockeye salmon at Spiridon River poses similar difficulties. In addition, the sacrifice of 100 (preferred sample size for genetic screening) sockeye salmon does not seem prudent since, for some years, the sampling could decimate the run. The primary purpose of characterizing the genetic baseline from the brood sources (Upper Station and Saltery Lakes) and Spiridon River sockeye salmon was to determine if individual stocks could be identified. If so, then in the event that Spiridon River sockeye salmon escapement appeared to increase substantially, the stock's genetic characteristics could be compared to the Spiridon Lake brood source's genetic characteristics to determine if the fish had strayed and perhaps to what extent. Hendry et al. (1996) investigated the genetic population structure of Lake Washington sockeye salmon using the analysis of variation in allele frequency at protein code loci. The distinctions noted within and among native and introduced groups were evaluated and resulted in evidence of genetically distinct populations. Similarly, preliminary analysis of the genetic differences of Upper Station and Saltery Lake stocks appear to indicate that identification between the brood sources may be possible (C. Habicht, ADF&G, Anchorage, personal communication). The 1994 sockeye salmon escapement observed at Spiridon River was the first reported for the system (T. Chatto, KNWR, Kodiak, personal communication). This may suggest that a portion of these fish were strays from the Spiridon Lake return; however, in 1996 the Spiridon Lake run was larger, with similar catches in SBTHA as in 1994, and only 100 sockeye salmon were observed in Spiridon River. The straying rate would be expected to be similar or larger than 1994, indicating that these fish are likely not strays. Also, if sockeye salmon observed at Spiridon

River are, indeed, strays, the straying rate is extremely low (<0.01%). Previous sockeye salmon research have indicated that straying is rare compared to other salmon species (Quinn 1985); sockeye populations tend to be isolated and quite specialized to a particular freshwater environment. Varnavskiy and Varnavskaya (1985) found that the straying rate between river systems ranged from 1.7%-2.6% for sockeye salmon. In Alaska, studies at Karluk and Brooks Lakes found similar straying rates; however, a broader range of 2.0%-6.8% was indicated (Hartman and Raleigh 1964). A similar straying rate of 2% (threshold) is used for evaluation of smolt releases at Kitoi Bay Hatchery (Hall et al. 1997; Honnold et al. *in press*); that is, straying to other sockeye systems on Afognak Island at or below this level is considered acceptable and due to natural biological dynamics. Substantial straying above this threshold then, perhaps, indicates that sockeye imprinting and homing is inadequate. The stocking of fry into freshwater lakes where juveniles reside for one to two years prior to emigrating as smolts is a common method to provide imprinting and homing of adult returns (Honnold et al. 1996). The "sensitive" period for olfactory imprinting appears to occur three to four weeks after the onset of smoltification (Cuenco et al. 1993; the total smoltification period was eight weeks for Atlantic salmon (Morin et al. 1989)). Thus, residence during this period in the freshwater source such as Spiridon Lake, which is intended as a target for homing is critical. The magnitude of runs to the SBTHA and the small number of sockeye that have been observed at Spiridon River (if assumed all to be strays), indicate successful imprinting by smolt in Spiridon Lake. There is little evidence at this time to indicate that the potential straying rate to Spiridon River is nearing the threshold level (2%). More thorough surveys to determine sockeye salmon escapement in Spiridon River would be beneficial. When escapements are determined to be at sufficient levels, (~1,000 fish), genetic sampling could then, perhaps, be accomplished with minimal impact to a presumed native sockeye salmon population.

Saltery Lake Sockeye As A Brood Source

When assessing a potential brood source for sockeye salmon stocking it is important to evaluate factors such as geographic proximity to the project (hatchery or release site), run timing and stock strength (escapement levels), and disease history McDaniel et al. (1994). In 1994, the ADF&G proposed to temporarily use Saltery Lake sockeye salmon fry for stocking of Spiridon Lake (ADF&G 1994). The ADF&G assessment of the brood stock change found that the biological, cultural, physical, subsistence, or economic resources of the westside of Kodiak Island in the area of Spiridon Bay would not be compromised. In addition, this assessment indicated that, in some instances, the use of Saltery Lake sockeye salmon as a brood source may have less impact on area resources than described in the project EA using Upper Station sockeye.

Presently, a brood stock source for the Spiridon Lake project is being developed at Kitoi Bay Hatchery (Figure 1), using late run Upper Station stock (Honnold and Clevenger 1995; Clevenger et al. 1996; Hall et al. 1996). Returns to the hatchery have been less than anticipated; thus, a donor stock egg collection is expected to be necessary in 1997 (Clevenger et al. 1997). Upper Station sockeye salmon may not be the appropriate donor stock for brood stock development at Kitoi Bay Hatchery or for fry stocking at Spiridon Lake. Specifically, Upper Station run timing appears problematic in terms of overlap with pink salmon run timing at both Kitoi Bay as well as Spiridon River. This overlap makes sockeye salmon brood collection difficult at Little Kitoi Lake as result of high interception rates during the fishery that targets pink salmon (Hall et al. 1997). Likewise, the harvest of Spiridon Lake bound sockeye salmon of Upper Station run timing results in incidental harvest of pink salmon bound for Spiridon River. Additionally, the potential for a reduced egg take at Upper Station Lakes as result of low late run escapement, and excessive logistical costs have also been identified as problems associated with the Upper Station sockeye brood stock (ADF&G 1994). Switching the brood stock for the stocking of Spiridon Lake (and brood stock development at Kitoi Bay) from late run Upper Station sockeye to Saltery Lake sockeye would appear to alleviate these problems.

The specific rationale for changing the brood stock from Upper Station Lake to Saltery Lake includes the following:

1) *The timing of Saltery Lake stock should reduce the incidental harvest of Spiridon River pink, and chum salmon stocks* due to greater separation in the run timing between Saltery Lake and Spiridon River salmon stocks (Appendix N.1; N.2). The sockeye run at Telrod Cove (Spiridon Bay Terminal Harvest Area) as a result of stocking Saltery Lake sockeye into Spiridon Lake is projected to occur from 04 July through 09 August, peaking 22 July (ADF&G 1994). The run (based on harvest in statistical fishing area 254-40) using late run Upper Station as brood stock has occurred from ~24 July through 04 September, and has peaked ~15 August. The incidental harvest of pink salmon has occurred primarily during the peak of the terminal fishery in mid August. The largest harvest of pink and chum salmon in the SBTHA in 1994-1996 occurred during the weeks ending 01 and 08 of August; however, over half of the overall incidental harvest of pink salmon occurred from 08 August-12 September. Few chum salmon have been harvested in the SBTHA; the incidental harvest of chum salmon in the SBTHA is not expected to increase with the change in sockeye salmon run timing since few chum salmon have been observed in the terminal harvest area and appear to be more directed in their movements toward Spiridon River (ADF&G 1994). The chum salmon harvest in Spiridon Bay (statistical area 254-40) has historically occurred from June through August, peaking in late July. This trend is not expected to change; however, should be monitored annually to assess any substantial change. The small Spiridon River sockeye run (~200-450 escapement) has been observed in the river from late August into early October (T.Chatto, USFWS, Kodiak, personal communication). The earlier sockeye run timing to Spiridon Lake would be expected to decrease the incidental harvest of Spiridon River sockeye since the fishery will occur primarily in July. Thus, the earlier timing of Spiridon Lake bound sockeye salmon as result of the use of Saltery Lake brood, may lessen incidental harvest of pink, chum, and sockeye salmon. The initial returns from 1994 stocking of Saltery Lake sockeye salmon fry are expected from 1997-1999; therefore, the incidental harvest of pink, and chum salmon can be assessed during this period to verify wild stock impacts.

   In Addition, Uganik and Little River Lake sockeye salmon were identified by the staff of KNWR as stocks that may have timing similar to Saltery Lake sockeye; thus, may be incidentally caught when Spiridon Lake bound fish are harvested (T. Chatto, KNWR, Kodiak, personal communication). This incidental harvest, in turn, may reduce escapements below minimum goals. In addition, the enhanced fish may stray into Uganik or Litter River Lakes possibly impacting wild stock spawners (disease transmission and genetic integrity). Uganik sockeye salmon are estimated to reach peak abundance in late June and about 10% of the run is during 6-25 July (Appendix N.3). Little River run timing estimates indicate about 95% of the run is before 5 July (Barrett and Nelson 1994). Saltery has a late June through early August run timing, where 50% of the run is estimated to occur during the 5-26 July period (Barrett and Nelson 1994). Thus, very little overlap (if any) of runs should occur; therefore, incidental harvest of Uganik and Little River Lake sockeye as result of harvest of Spiridon Lake bound sockeye will likely be minimal. The timing differences between Saltery stock (Spiridon Lake bound) and Uganik and Little River Lakes sockeye would also be expected to reduce the potential for straying. This potential is expected to be minimal, as previously discussed, due to the rarity of straying in sockeye salmon (Quinn 1985). In addition, genetic research at Frazer Lake indicates a high degree of spawning location affinity for donor stocks and introduced populations of sockeye salmon (Burger et al. *in press*). That is, introduced subpopulations of sockeye salmon will spawn in locations that parallel areas which donor stocks spawn in their natal system (i.e. tributaries, lake shoals). Saltery Lake sockeye are primarily tributary spawners (L.Malloy, KRAA, Kodiak, personal communication). Little River (C.Swanton, ADF&G, Kodiak, personal communication), as well as Spiridon River (T.Chatto, KNWR, Kodiak, personal communication) sockeye salmon are predominantly shoal spawners while Uganik Lake has components of both type of spawners (C.Swanton, ADF&G, Kodiak, personal communication). Thus, strays to the former systems would not be expected to overlap with wild stocks on the spawning grounds. This may reduce the potential for disease or other impacts (displacement of spawners) due to straying. It would be prudent to further assess spawning locations for Little River and Uganik Lake sockeye as well as collect baseline genetic data in order to differentiate stocks.

Existing management strategies are not expected to be altered to accommodate increased Spiridon sockeye runs. However, the use of Saltery sockeye as the brood stock may require SBTHA to be open to commercial fishing earlier than previous years due to the earlier run timing. Thus, ADF&G field personnel may need to be on site in anticipation of earlier openings. There may also be additional run reconstruction sampling costs to investigate other harvest areas than are currently defined (C. Hicks, ADF&G, Kodiak, personal communication). Also, the current run reconstruction program may fail to detect Spiridon bound sockeye with reasonable precision if the freshwater scale pattern changes markedly due to increased fry loadings into the lake. Increased catches may actually provide more efficient area specific sampling which would also allow in season assessment of scale pattern changes.

2) *The run timing will provide improved opportunity for escapements necessary for the Little Kitoi Bay brood stock development program* (Appendix O). Sockeye runs using Saltery Lake broodstock would be expected to return as chum salmon abundance in the Kitoi Area is declining, and prior to the majority of the pink salmon returns. This would provide an opportunity to allow sufficient escapement into Little Kitoi Lake for broodstock requirements.

3) *The utilization of excess escapement of Saltery Lake sockeye may benefit the Saltery Lake zooplankton community* which has experienced a decline in density and biomass in recent years of excess escapements. Sockeye escapement (averaged 53,400) has exceeded the targeted BEG (40,000) each year since 1991. Large escapements can result in excess production of fry and potentially exceed the density dependent threshold in lakes (Kyle et al. 1988; Edmundson et al.

1993; Koenings and Kyle 1996). This may result in inter and intra-specific competition for macrozooplankton and, in turn, will limit rearing capacity and may cause brood year interactions (Kyle 1996). There is some evidence that Saltery Lake may be exhibiting a negative response to excess escapements (Honnold et al. *in press*). The 1996 TMZ biomass (227 mg m^2) declined four-fold from 1995 (1053 mg m^2). Thus, the utilization of excess spawners at Saltery Lake for egg collection may benefit production by preventing excess fry loading in a potential depressed rearing environment. The removal of excess spawners (~6,000) necessary for brood collection for the Spiridon Lake and other late run stocking project may not make a large impact for years when escapements are significantly higher than targeted goals. Eggs will not be collected when minimum escapement goal (20,000) is not reached; 50% of those spawners in excess of the minimum will be available for an egg take once this goal is achieved (Clevenger et al. 1997)

4) *The cost benefit ratio of the program will improve as a result of decreased egg take costs at Saltery Lake.* Saltery Lake is located much closer to PCH than Upper Station Lakes (Figure 1). Consequently, air charter costs would be reduced for egg take logistics and transport of eggs to the hatchery. In addition, Saltery Lake is accessible by four-wheeler from the Kodiak road system which allows egg takes to proceed if weather prevents flying. This would reduce the length of the remote camp operation and associated personnel and logistical costs as well as safety concerns. Reducing egg take costs and risks to production are especially important with the currently reduced market value of salmon; the more efficient the production of fry, the greater benefits to participants that harvest returns.

5) *The use of Saltery Lake sockeye salmon as a brood source for the Spiridon Lake stocking also appears to provide fish culture benefits.* Saltery Lake fry grow faster in the hatchery with less mortality than Upper Station stock (C. Clevenger, ADF&G, Kodiak, personal communication). Size at emergence is larger and target stocking sizes are reached more efficiently during rearing. These attributes may well improve survival as indicated by the initial smolt emigration in 1996 (~18% fry to smolt survival for age-1 migrants).

6) *The probability of IHNV transmission to Spiridon River chum or sockeye salmon is not expected to be any higher or lower if Saltery sockeye salmon are used for stocking Spiridon Lake versus the Upper Station late run fish* (ADF&G 1994). The resident stock (assuming are not strays) likely carry the virus (Ted Meyers, ADF&G, Juneau, personal communication). Hence, chum salmon and resident sockeye salmon were probably exposed naturally to IHN virus prior to any introductions of other sockeye stocks (strays). The Upper Station and Saltery Lakes sockeye stocks are both IHNV carriers. Although the annual prevalence of the virus has varied for each stock, a significant concentration of IHNV is released into the environment regardless of the number of positive screenings (Ted Meyers, ADF&G, Juneau, personal communication). For example, one infected adult fish could result in an IHNV prevalence of 100% in spawning adult sockeye salmon. There appears to be little difference between a low or moderate prevalence versus a high prevalence of the virus in the population. In either case, all fish would become infected over time. Despite this previous virus prevalence, the Upper Station Lake stock was acceptable for use in the 1991 EA. Another consideration is that IHNV levels within sockeye stocks can fluctuate (very low prevalence to very high prevalence) from year to year and even within the same year (Ted Meyers, ADF&G, Juneau, personal

communication). This fact is supported by the historic variation at Upper Station and Saltery Lakes where IHNV prevalence has been cyclic. These prevalence values represent one point in time and may vary considerably if sampling had occurred at different times. This variation is also dependent upon what segment of the run was sampled and the environmental conditions at the time of sampling. Environmental conditions (low water and flows, high temperatures) can influence horizontal transmission (fish to fish) of the virus from a few returning carrier fish. High fish densities along with less than optimum environmental conditions will result in stress, greater virus production, and larger exposure. This translates to a higher prevalence and titers of virus in the population. Also, the brood stock prevalence of virus is not directly proportional to the level of virus that may occur in the progeny fish (Ted Meyers, ADF&G, Juneau, personal communication). High levels of virus in adult spawners is a threat to fish culture but not necessarily to juvenile fish after transplant. Once fry are stocked most of their virus exposure will come from other adult or resident sockeye salmon. Statewide ADF&G policy procedures employed for the culture of sockeye salmon greatly reduces exposure of progeny fish to virus from the adult parent fish (ADF&G 1988; McDaniel et al. 1994). Finally, as previously discussed, straying of sockeye salmon is infrequent compared to other salmonid species (i.e. chinook) as long as juveniles are imprinted properly in freshwater (Quinn 1985).

The use of Saltery Lake stock as an fry source for stocking of Spiridon Lake does not appear to increase the potential of IHNV exposure or infection of the resident fish in Spiridon Lake or the wild anadromous stocks in nearby systems. The current brood source (Upper Station) poses equivalent risks and has been approved by the project EA (KNWR 1991).

RECOMMENDATIONS

1. Stocking level be increased incrementally; the next three years the range of stocking should be 5 to 7 million fry (G.Kyle, ADF&G, Soldotna, personal communication). Evaluation of the forage base (zooplankton sampling) should continue as long as the lake is being stocked. Zooplankton abundance, size, and species composition information should be used to assess impacts of stocking and to adjust annual fry stocking levels. The ultimate stocking level should produce age-1 smolts ≥85 mm/5 g; however, should be assessed annually based on zooplankton sampling results and retention of the distinct freshwater scale pattern.

2. Limnological and juvenile sockeye sampling should continue. Specifically, the once per month collection of zooplankton and water samples should be continued from May-September to assess the forage base and water chemistry; hydroacoustic surveys and qualitative smolt sampling should continue to estimate rearing fry populations, smolt emigrations, and their age, and size to assist with stocking strategies; presmolt stocking (late fall) should be considered in addition to or as an alternative to fry plants, depending upon the zooplankton response to stocking in the future; the smolt bypass should continue to be operated to pass smolt by the barrier falls to minimize mortality.

3. Resident fish sampling in Spiridon Lake, Spiridon Bay wildlife surveys, and IHNV and sampling of Spiridon River sockeye salmon should be discontinued as sufficient data have

been collected; genetic sampling of Spiridon River sockeye should only be conducted if escapements exceed 1,000 salmon.

4. Index escapement surveys of Spiridon River should be expanded. A minimum of eight aerial surveys should be conducted, annually; four surveys (from late July through early September) should be conducted of the entire system to define potential index areas and increase the reliability of pink and chum salmon escapement estimates.

5. The deployment of a barrier net in Telrod Cove to prevent excess sockeye salmon from escaping into Telrod Creek should be continued on a permanent annual basis. Each year during net operation, the minimum pink salmon escapement (~100) will be passed over the net for access to Telrod Creek. The net (and ADF&G camp) should be deployed from ~ 15 June through 10 September in 1998 and 1999 to provide for earlier run timing projected for Spiridon bound fish of Saltery Lake donor stock. This deployment will be necessary on an annual basis if Saltery Lake sockeye replace Upper Station sockeye as the donor stock for the project.

6. The present North West Kodiak District Management Plan, as detailed in the 1996 Kodiak Commercial Salmon Harvest Strategy (Prokopowich et al. 1997), should not be compromised or changed by this enhancement project. A high proportion of the sockeye salmon returning to Spiridon Lake are expected to be harvested in the NW District. This fishery should continue to be operated by an initial opening based on sockeye salmon build-up in Telrod Cove (SBTHA) with continuous fishing time in SBTHA until the run ends.

7. The commercial harvest of Spiridon Lake sockeye salmon should continue to be estimated within the Northwest, Southwest, and Afognak (southwest section) Districts each year. Run reconstruction methods should parallel those of 1994-1996 and include estimating the age composition of escapements and catches, visual identification of Spiridon Lake sockeye by scale pattern analysis, determination of stock compositions, and then estimating the Spiridon Lake component of the harvest. Run timing should also continue to be assessed each year. The freshwater scale pattern should be assessed annually for changes as result of stocking densities.

8. Saltery Lake sockeye salmon should be used as the primary brood source for fry stocking at Spiridon Lake beginning in 1997 (stocking in 1998). This change will be contingent upon ADF&G approval through completion of Pillar Creek Hatchery Basic Management Plan (KRAA and ADF&G in press); Pillar and Kitoi Bay Annual Management Plans; and Fish Transport Permits, as well as KNWR approval through inclusion in the Spiridon Lake Management Plan. The weir at Saltery Lake should continue to be operated and age samples collected to assure sufficient escapement to meet goals and provide brood fish. Brood stock should be sampled for age. The zooplankton community should be monitored to assess any changes in response to high escapements. Run timing, age structure and magnitude of returns to Spiridon Lake as a result of Saltery Lake brood in 1994, should be evaluated from 1997-1999. If run timing, and other factors as described in this document are determined compatible with ADF&G and KNWR goals, then the change in the project brood stock to Saltery Lake sockeye should be implemented on a permanent basis.

9. Tissue samples should be collected from sockeye salmon at Uganik and Little River Lakes in 1997, in conjunction with the brood stock change, to determine baseline genetic characteristics. Lake Rose Tead sockeye salmon should also be sampled for genetics since it is a likely candidate as an back-up brood source due to similar run timing as Saltery Lake sockeye. Each system, as well as Saltery Lake, should also be surveyed to further determine spawning locations.

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Table 1. Summary of seasonal mean water chemistry parameters by station and depth for Spiridon Lake, 1988-1996.[a]

Year	Sta ion	Depth (m)	Sp. Cond. (μ mhos cm^{-1})	S.D.	pH (Units)	S.D.	Alkalinity (mg L^{-1})	S.D.	Turbidity (NTU)	S.D.	Color (Pt units)	S.D.	Calcium (mg L^{-1})	S.D.	Magnesium (mg L^{-1})	S.D.	Iron (μ g L^{-1})	S.D.
1988	1	1	71.5	1.0	7.1	0.2	20.8	1.7	0.6	0.3	7.0	2.3	6.1	1.0	2.3	0.5	17	3
1988	1	50	71.5	0.6	7.0	0.1	20.5	1.3	0.6	0.4	5.8	0.5	6.1	0.8	2.2	0.7	12	3
1988	2	1	71.7	0.6	7.1	0.2	20.0	1.0	0.4	0.1	8.0	0.0	7.7	2.8	1.3	1.6	16	6
1988	2	50	71.6	0.5	7.0	0.1	19.4	0.9	0.7	0.5	7.4	2.8	5.4	0.2	3.2	1.0	15	7
1989	1	1	75.0	6.2	7.3	0.2	22.2	2.8	0.3	0.1	13.8	6.4	5.7	1.0	2.0	0.3	9	4
1989	1	50	76.8	8.6	7.3	0.2	22.8	3.5	0.3	0.1	12.4	3.8	6.3	0.6	2.3	0.7	12	9
1989	2	1	73.6	1.5	7.3	0.2	21.4	0.9	0.7	0.6	12.0	3.9	5.9	0.4	2.4	0.4	25	35
1989	2	50	72.6	1.7	7.3	0.1	20.2	4.1	0.8	0.9	14.4	6.2	5.8	0.6	2.4	0.7	84	144
1990	1	1	76.2	7.2	7.4	0.2	23.7	2.6	0.5	0.4	5.0	1.9	5.7	0.9	2.2	0.6	14	9
1990	1	50	73.2	1.9	7.3	0.2	23.4	1.5	0.5	0.4	4.8	0.8	6.1	0.6	2.3	0.6	16	8
1990	2	1	73.0	1.2	7.4	0.1	23.2	1.3	0.5	0.3	6.0	2.8	6.3	0.5	2.0	0.5	19	7
1990	2	50	73.2	0.8	7.3	0.2	23.0	1.6	0.5	0.4	5.8	2.9	5.7	0.8	2.5	0.6	16	12
1991	1	1	83.7	23.5	7.3	0.1	21.1	3.6	0.7	0.4	6.6	2.2	6.1	0.4	2.4	0.8	23	24
1991	1	50	75.4	4.0	7.3	0.1	22.1	2.0	1.5	2.1	7.4	3.9	6.2	0.7	2.4	0.5	114	232
1991	2	1	74.3	4.4	7.4	0.1	23.0	0.6	0.7	0.5	8.4	5.9	6.4	0.4	2.3	0.3	22	14
1991	2	50	75.0	1.7	7.3	0.2	25.9	8.0	0.8	0.4	6.1	4.1	6.1	0.6	2.2	0.4	29	25
1992	1	1	72.8	1.3	7.1	0.1	20.4	0.8	0.7	0.3	4.2	0.4	5.9	0.7	2.5	0.8	21	9
1992	1	50	74.3	0.5	7.1	0.1	20.8	0.4	0.5	0.1	8.0	4.8	6.2	0.5	2.3	0.5	20	9
1992	2	1	74.2	0.8	7.2	0.1	21.0	0.0	0.6	0.3	8.2	4.3	6.2	0.7	2.5	1.0	18	8
1992	2	50	73.8	0.4	7.0	0.1	20.7	0.4	0.7	0.5	4.2	2.5	6.0	0.9	2.2	0.4	15	4
1993	1	1	80.3	5.2	7.3	0.6	23.1	2.5	1.1	1.3	3.5	0.8	6.7	1.6	2.2	0.6	16	10
1993	1	50	89.2	28.0	7.0	0.4	22.3	2.3	1.0	0.6	3.5	0.8	6.2	0.7	2.8	1.0	23	15
1993	2	1	79.8	5.6	7.3	0.6	23.6	2.8	0.8	0.6	4.8	2.4	6.5	1.2	2.5	0.4	15	8
1993	2	50	78.3	2.4	7.0	0.1	21.8	0.8	0.4	0.1	4.5	2.1	6.1	0.6	2.5	0.4	14	7
1994	1	1	77.3	0.8	6.9	0.4	21.8	1.3	0.4	0.1	8.5	1.5	6.3	0.5	2.2	0.3	8	9
1994	1	50	78.7	2.3	6.9	0.3	21.9	0.9	0.3	0.1	8.0	1.5	6.3	0.5	2.4	0.7	5	4
1994	2	1	77.3	1.0	7.0	0.3	22.1	0.8	0.4	0.1	9.2	2.3	6.1	0.4	2.5	0.7	18	25
1994	2	50	77.7	0.8	6.9	0.3	22.3	0.9	0.7	0.9	7.8	3.3	6.1	0.4	2.3	0.3	31	48
1995	1	1	76.0	3.1	6.8	0.1	21.7	0.5	1.0	0.7	4.2	1.5	5.6	0.2	2.4	0.3	11	5
1995	1	50	75.4	1.5	6.9	0.1	22.5	2.0	0.7	0.5	5.5	2.3	5.8	0.5	2.8	0.8	9	6
1995	2	1	76.3	2.8	7.0	0.1	22.3	0.7	0.7	0.6	3.7	1.2	5.8	0.3	2.3	0.5	11	6
1995	2	50	76.0	2.0	6.9	0.2	22.8	1.2	0.7	0.6	6.3	4.6	5.8	0.3	2.3	0.5	11	5
1996	1	1	77.0	2.8	7.0	0.2	22.4	0.6	0.6	0.2	4.2	0.8	5.5	0.1	2.6	0.2	11	4
1996	1	50	77.3	3.0	7.0	0.1	22.6	1.1	0.6	0.3	4.8	1.8	5.5	0.1	2.6	0.2	9	4
1996	2	1	76.8	1.5	7.2	0.1	22.0	0.4	0.6	0.4	4.0	0.6	5.5	0.1	2.6	0.2	14	10
1996	2	50	77.7	2.4	7.0	0.1	22.0	0.5	0.6	0.2	5.8	3.5	5.5	0.1	2.6	0.2	8	1

[a] Table revised from G. Kyle, ADF&G, Soldotna, personal communication.

Table 2. Summary of seasonal mean nutrient and algal pigment concentrations by station and depth for Spiridon Lake, 1988-1996.[a]

Year	Station	Depth (m)	Total - P ($\mu g L^{-1}$)	S.D.	Total filterable - P ($\mu g L^{-1}$)	S.D.	Filterable reactive - P ($\mu g L^{-1}$)	S.D.	Total Kjeldahl - N ($\mu g L^{-1}$)	S.D.	Ammonia ($\mu g L^{-1}$)	S.D.	Nitrate + nitrite ($\mu g L^{-1}$)	S.D.	Reactive silicon ($\mu g L^{-1}$)	S.D.	Chlorophyll *a* ($\mu g L^{-1}$)	S.D.
1988	1	1	3.8	1.4	3.0	1.1	2.5	1.2	102.8	11.4	9.9	2.7	220.5	26.0	2,171	160	0.45	0.09
1988	1	50	3.8	0.6	2.2	0.6	1.7	0.5	94.9	9.0	11.2	5.5	256.9	9.6	2,279	172	0.16	0.06
1988	2	1	3.5	0.1	2.0	0.6	1.8	0.3	100.5	11.3	7.8	6.6	221.3	11.1	2,283	170	0.40	0.10
1988	2	50	4.0	0.6	1.9	0.6	1.8	0.5	91.4	9.9	8.6	4.4	236.2	27.5	2,237	157	0.29	0.12
1989	1	1	3.6	0.7	3.7	1.9	3.0	2.2	103.4	7.6	8.5	2.5	207.1	35.4	2,162	214	0.19	0.11
1989	1	50	4.2	1.0	3.2	1.2	2.4	0.4	97.9	18.6	11.5	7.3	242.8	54.9	2,277	353	0.32	0.18
1989	2	1	6.1	3.7	2.7	1.0	2.5	0.4	114.8	45.7	9.5	5.2	197.9	61.9	2,129	119	0.18	0.13
1989	2	50	7.3	7.8	2.7	0.7	2.7	0.7	104.0	40.1	12.5	11.0	209.8	50.4	2,173	109	0.37	0.28
1990	1	1	3.5	1.8	2.4	0.6	2.0	0.8	92.5	16.5	4.9	2.0	203.4	36.8	2,114	93	0.23	0.11
1990	1	50	3.0	0.7	2.8	0.5	2.0	0.6	85.3	10.9	6.3	2.5	228.5	24.8	2,171	96	0.34	0.21
1990	2	1	2.4	0.6	4.1	3.2	3.3	2.4	83.2	6.4	4.7	1.7	185.0	79.4	2,127	80	0.24	0.09
1990	2	50	2.5	0.8	2.8	1.1	2.9	1.9	87.7	12.3	6.6	2.8	187.3	80.1	2,205	109	0.24	0.12
1991	1	1	4.9	5.9	2.8	0.8	2.6	0.9	93.7	7.3	7.6	4.4	234.0	38.1	2,082	57	0.38	0.14
1991	1	50	5.2	3.7	3.3	2.0	2.8	1.4	87.5	12.9	9.4	4.8	265.1	20.9	2,131	54	0.20	0.09
1991	2	1	3.6	0.8	4.8	3.3	4.6	3.3	91.8	8.6	8.2	4.5	237.0	29.6	2,081	66	0.35	0.12
1991	2	50	3.8	1.5	3.6	3.3	3.4	3.2	88.6	7.4	11.3	5.8	267.7	7.7	2,137	46	0.25	0.14
1992	1	1	3.7	0.6	2.1	0.7	1.5	0.5	89.6	10.1	1.5	0.8	239.5	12.3	2,082	131	0.27	0.15
1992	1	50	4.9	1.4	4.2	3.1	3.7	3.0	87.0	8.0	4.6	3.3	258.7	16.9	2,111	102	0.22	0.07
1992	2	1	3.6	0.3	2.6	1.4	2.4	1.4	98.4	18.2	1.7	0.6	235.2	25.9	2,025	90	0.27	0.21
1992	2	50	4.5	0.8	3.1	2.8	2.0	1.1	83.2	24.8	5.3	3.7	273.4	7.7	2,112	46	0.23	0.11
1993	1	1	2.7	0.9	2.2	1.1	1.6	0.8	93.6	11.2	2.4	1.5	231.6	37.6	2,023	164	0.75	0.24
1993	1	50	3.0	0.9	3.0	4.0	1.8	1.8	90.7	10.8	5.2	3.4	240.2	22.8	2,122	94	0.42	0.20
1993	2	1	2.9	1.0	3.2	3.5	2.6	3.3	97.0	12.0	1.8	0.5	230.3	41.5	2,026	163	0.77	0.29
1993	2	50	2.5	0.1	3.2	2.5	2.8	2.5	85.4	3.8	5.4	3.7	247.7	30.6	2,128	96	0.40	0.22
1994	1	1	3.2	1.3	1.9	1.5	1.5	1.1	101.8	3.9	3.2	4.7	204.3	22.1	2,092	131	0.26	0.21
1994	1	50	3.9	2.0	1.2	0.2	1.1	0.4	97.5	16.1	6.7	3.6	218.1	18.3	2,184	95	0.21	0.13
1994	2	1	2.8	0.7	2.2	1.5	1.4	0.9	105.7	12.8	1.6	1.3	202.1	17.2	2,144	77	0.31	0.15
1994	2	50	3.3	1.2	2.2	1.3	1.9	1.1	105.6	13.2	5.8	2.5	225.7	20.6	2,190	85	0.20	0.07
1995	1	1	3.4	2.2	0.9	0.1	0.9	0.2	108.8	12.3	2.2	1.6	203.1	26.8	2,300	95	0.95	0.49
1995	1	50	3.4	1.3	1.5	0.3	1.4	0.4	105.6	20.4	3.5	2.4	241.6	6.6	2,340	105	0.58	0.44
1995	2	1	3.9	2.0	1.2	0.4	1.1	0.2	125.2	24.1	2.2	1.0	213.4	19.8	2,297	75	1.02	0.41
1995	2	50	3.2	0.9	0.9	0.2	0.9	0.1	108.2	18.6	4.5	3.0	243.1	9.1	2,329	102	0.58	0.45
1996	1	1	2.7	0.6	1.5	0.9	1.0	0.5	113.4	34.1	5.1	2.8	183.6	18.5	2,042	93	0.49	0.16
1996	1	50	3.0	1.1	1.3	0.7	1.0	0.4	90.5	18.5	9.3	5.0	210.8	9.0	2,148	51	0.51	0.23
1996	2	1	2.7	0.7	1.4	0.7	1.1	0.3	105.5	20.7	5.6	1.6	180.2	14.4	2,083	82	0.47	0.14
1996	2	50	4.4	1.7	1.5	0.7	1.5	1.3	101.1	16.9	10.2	4.1	217.9	2.4	2,179	82	0.57	0.33

[a] Table revised from G. Kyle, ADF&G, Soldotna, personal communication.

Table 3. Spiridon Lake weighted mean zooplankton density (No./m^3) and biomass (mg/m^3),by species, 1987-1996.[a]

Year	*Diaptomus*		*Cyclops*		*Bosmina*		*Daphnia*		*Holopedium*		Totals	
	Density No./m^3	Biomass mg/m^3	Density No./m^3	Biomass mg/m^3	Density No./m^3	Biomass mg/m^3	Density No./m^3	Biomass mg/m^3	Density No./m^3	Biomass mg/m^3	Density No./m^3	Biomass mg/m^3
1987	2,627	10	4,506	9	1,306	4	1,083	3	111	2	9,633	27
1988	1,067	5	2,939	7	724	3	381	3	15	0.08	5,126	17
1989	1,909	6	6,356	8	671	2	379	2	67	0.46	9,382	18
1990	2,228	9	4,134	8	424	1	601	4	30	2	7,416	24
1991	2,276	8	6,587	11	136	0.40	659	3	16	0.36	9,673	23
1992	407	3	5,222	15	237	1	498	2	36	0.32	6,399	21
1993	221	1	5,395	9	324	1	479	1	75	1	6,494	13
1994	162	1	4,819	9	559	2	788	2	155	1	6,483	15
1995	256	2	4,271	10	597	1	579	2	397	3	6,100	18
1996	57	0.2	7,692	16.6	565	1.8	417	1.5	177	1.5	8,908	22
mean 87-89	1,868	7	4,600	8	900	3	614	2	64	1	8,047	21
mean 90-96	801	3	5,446	11	406	1	575	2	127	1	7,353	19

[a] Data provided by G. Kyle, ADF&G, Soldotna, personal communication.

Table 4. Seasonal weighted mean lengths (mm) of zooplankton taxa in Spiridon Lake, 1988-1996.[a]

Year	*Diaptomus*	*Cyclops*	*Bosmina*	*Daphnia*	*Holopedium*
1988	1.02	0.82	0.61	1.20	0.73
1989	0.89	0.60	0.56	0.98	0.82
1990	1.00	0.76	0.59	1.10	0.69
1991	0.94	0.71	0.56	0.99	0.76
1992	1.14	0.91	0.60	1.02	0.91
1993	1.06	0.71	0.52	0.81	0.83
1994	1.09	0.75	0.55	0.75	0.81
1995	1.30	0.79	0.51	0.77	0.83
1996	0.95	0.79	0.58	0.92	0.86
Mean	1.04	0.76	0.56	0.95	0.80

[a] From G.Kyle, ADF&G, Soldotna, personal communication.

Table 5. Summary of the composition of cladocerans and copepods in Spiridon Lake, 1988-1996.[a]

Year	Cladoceran density (no. m^{-3})	Cladoceran composition	Copepod density (no. m^{-3})	Copepod composition	Cladoceran to Copepod ratio
1988	1,120	22%	4,006	78%	0.28
1989	1,117	12%	8,265	88%	0.14
1990	1055	14%	6361	86%	0.17
1991	811	8%	8862	92%	0.09
1992	770	12%	5,628	88%	0.14
1993	878	14%	5,616	86%	0.16
1994	1,502	23%	4,981	77%	0.30
1995	1,573	26%	4,527	74%	0.35
1996	1,160	13%	7749	87%	0.18
Mean[b]	1,110	16%	6,222	84%	0.20

[a] From G.Kyle, ADF&G, Soldotna, personal communication.

Table 6. Sockeye salmon fry stocked into Spiridon Lake and smolts produced, 1990-1996.

Fry Stocking Year	Fry Stocked (millions)	Stocking Size (g)	Smolts Produced by Age (millions)				Fry to Smolt Survival (%)
			Age 1	Age 2	Age 3	Total	
1990	0.3	1.4	[a]	0.016	0.007	0.023	7.7
1991	3.5	0.23	1.468	0.116	0.003	1.587	45.3
1992	2.2	0.2	0.235	0.221	0.002	0.458	20.8
1993	4.2	0.25	0.625	0.231	0.002	0.858	20.4
1994	5.7	0.18	0.362	0.251	[b]	0.613	10.8
1995	4.6	0.35	0.803	[b]	[b]	0.803	17.5
1996	4.8	0.3	[b]	[b]	[b]	[b]	[b]

[a] Smolts migrated over falls in 1991; since 1992 smolts have migrated past falls via pipeline.

[b] Smolts of this age class have not migrated.

Table 7. Spiridon Lake sockeye smolt estimates, 1992-1996.

	Smolt Outmigration			
Year	**Total**	**Mortality**	**% Mortality**	**Total Live**
1992	1,484,821	87,169	5.9	1,397,652
1993	345,558	15,433	4.5	330,125
1994	850,348	3,123	0.4	847,225
1995	614,992	21,030	3.4	593,962
1996	1,055,186	23,120	2.2	1,032,066

Table 8. Spiridon Lake sockeye smolt mean age composition, size, and condition, 1991-1996.

Year	Sample Size	Freshwater Age	Age (%)	Weight (g)	Length (mm)	Condition (K)
1991	596	1	100	19.3	127	1.08
1992	1,389	1	98.9	12.7	115	0.81
	14	2	1.1	58.9	183	0.80
1993	493	1	66.8	13.4	116	0.83
	240	2	33	33.8	155	0.88
	2	3	0.2	50.7	178	0.90
1994	929	1	73.5	9.3	106	0.78
	344	2	26.2	28.5	152	0.79
	4	3	0.3	145.8	254	0.88
1995	999	1	60.9	9.2	104	0.81
	667	2	38.8	25.1	138	0.95
	5	3	0.2	102.8	244	0.84
1996	1,573	1	76.1	10.3	109	0.79
	513	2	23.7	20.7	141	0.73
	5	3	0.2	85.6	221	0.77

Table 9. Dolly Varden catch-per-unit-effort as result of gillnetting in Spiridon Lake, 1991-1995.

	Year				
Location	**1991**	**1992**	**1993**	**1994**	**1995**
South Creek	0.41	0.63			
West Creek	0.49	3.00	2.81	1.20	2.01
East Creek	0.74	2.43			
Average	0.55	2.02	2.81	1.20	2.01

Table 10. Length frequency distribution of Dolly Varden captured by gillnet in Spiridon Lake, 1991-1995.

Length Range (mm)	Length Frequency Numbers						
	1991	1992	1993	1994	1995	Total	%
51-100	0	0	0	0	1	1	0.2
101-149	0	2	1	1	2	6	1.2
150-200	9	14	40	4	15	82	16.9
201-250	21	8	42	10	36	117	24.1
251-300	9	9	4	38	25	85	17.5
301-350	17	3	4	12	10	46	9.5
351-400	20	8	6	12	12	58	11.9
401-450	14	11	19	9	8	61	12.6
451-500	4	3	8	8	2	25	5.1
501-550	0	0	0	5	0	5	1.0
Totals/Year	94	58	124	99	111	486	100.0

Table 11. The number of beach seine sets and species captured in Spiridon Lake, 1991-1995.

Years Sampled	Number of Sets	Dolly Varden Adult	Dolly Varden Juvenile	Stickleback	Sculpin	Sockeye
1991	28	12	16	635	1,812	-
1992	50	278	84	3,550	1,866	149
1993	10	29	5	2,141	79	12
1994	12	40	1	1,022	134	407
1995	12	27	0	1,433	94	104

Table 12. Number of commercial fishers[a] fishing in the Spiridon Bay Terminal Harvest Area, 1994-1996.

Date		Number of Fishers 1994	1995	1996	Date		Number of Fishers 1994	1995	1996
July	20		3		September	1	17	2	4
	21		7			2	12	3	4
	22		2			3	8	1	6
	23		3			4	7	3	5
	24		2			5	6	2	3
	25		2			6	5	2	1
	26		7			7	4	0	3
	27		3			8	5	0	2
	28		5			9	3	0	1
	29		3	32		10	2	0	1
	30		3	21		11	2	2	0
	31		5	16		12	0	0	0
						13	0	0	0
August	1		5	17		14	1	0	0
	2		3	17		15	1	0	0
	3		6	22		16	1	0	0
	4	16	5	13		17	1	0	0
	5		4	17		18	0	0	0
	6		3	21		19	0	0	0
	7		4	15	Total Days		37	49	44
	8		3	16					
	9		3	18					
	10	27	7	21					
	11	28	5	17					
	12	28	2	12					
	13	33	4	19					
	14	34	6	14					
	15	28	4	18					
	16	27	6	8					
	17	21	6	20					
	18	15	4	23					
	19	25	3	28					
	20	21	3	25					
	21	20	2	25					
	22	20	0	21					
	23	8	3	17					
	24	13	4	13					
	25	12	1	13					
	26	9	2	9					
	27	12	2	10					
	28	0	2	9					
	29	12	3	9					
	30	11	4	6					
	31	10	2	3					

[a] as indicated by the number of vessels observed fishing.

Note: A "0" signifies no vessels fishing.

Table 13. Estimated age composition of sockeye salmon catch from Uganik Bay (253-11-35), post 14 July 1994-1996.[a]

			AGES																	
Year	Sample Size		0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	4.2	4.3	Total
1994	2,582	Percent	0	1.1	0.4	2.3	44.2	1.4	0	9.4	26.8	0.5	0.1	6.7	6.3	0.8	0.2	0	0	100
		Numbers	0	2,269	817	4,780	90,940	2,864	0	19,273	55,219	931	146	13,701	13.007	1,679	348	0	0	205,978
1995	2,103	Percent	0	0.8	3.7	1.6	18.8	1.5	0	13.7	28.4	0.1	0	17.9	12.8	0	0.6	0	0	100
		Numbers	0	1,588	7,530	3.358	38,405	3,115	101	27,970	58,083	145	81	36,511	26,206	81	1,126	0	0	204,299
1996	3,201	Percent	0	0.5	0.2	0.3	39.3	1.0	0	23.6	24.2	0	0.1	6.6	3.3	0	0	0	0	100
		Numbers	160	1,661	814	1,082 1	29,123	3,355	0	77,501	79,532	0	434	21,821	10,982	332	1,121	154	154	328,224

[a] Refer to Figure 4 for Statistical Areas; data from Nelson and Barrett (1994); Nelson and Swanton (1996); Nelson and Swanton (1997).

Table 14. Estimated age composition of sockeye salmon catch from Uyak Bay (254-10-40), post 14 July, 1994-1996.[a]

			AGES															
Year	Sample Size		0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	4.2	4.3	3.4	Total
1994	3,069	Percent	0.2	0	1.3	49.9	0.2	7.0	26.3	0.1	0.1	4.1	9.3	0	1.3	0	0	0.1	100
		Numbers	477	62	3,069	116,914	359	16,501	61,729	271	144	9,712	21,698	107	3.092	31	0	149	234,305
1995	3.319	Percent	1	3	1	12	1	10	30	0	0	18	22	0	2	0	0	0	100
		Numbers	1,817	7,566	3,998	36,218	1,507	30,861	90,350	441	672	52,772	66,577	0	4,319	148	0	0	297,243
1996	2,388	Percent	1	0	0	34	0	6	44	0	0	6	8	0	2	0	0	0	100
		Numbers	1,095	29	689	63,984	325	11,858	83,222	29	0	10,660	14,186	25	3,572	88	146	0	189,909

[a] Refer to Figure 4 for Statistical Areas; data from Nelson and Barrett (1994); Nelson and Swanton (1996); Nelson and Swanton (1997).

Table 15. Estimated age composition of Spiridon Bay Terminal Harvest Area (SBTHA) sockeye salmon catch, 1994-1996.[a]

			Ages %										
Year	**Sample Size**		**0.2**	**1.1**	**0.3**	**1.2**	**2.1**	**1.3**	**2.2**	**2.3**	**3.1**	**3.2**	**Total**
1994	1,329	Percent	0	0.1	0	99.5	0.3	0	0	0	0	0	100
		Numbers	0	149	0	114,624	356	30	21	9	0	0	115,188
1995	1,313	Percent	0.1	19.9	0.1	60.2	1.9	4.9	11.6	1.3	0	0	100
		Numbers	19	6,312	37	19,089	595	1,563	3,667	409	0	0	31,692
1996	1,875	Percent	0	1.8	0	79.0	4.6	0.2	14.3	0	0.1	0.1	100
		Numbers	0	2,846	0	128,123	7,448	303	23,192	0	111	97	162,118

[a] Refer to Figure 2,3, and 4 for location; data from Nelson and Barrett (1994); Nelson and Swanton (1996); Nelson and Swanton (1997).

Table 16. Estimated number of Spiridon Lake sockeye salmon harvested in Uganik Bay, Uyak Bay and SBTHA by week, 1994 -1996.[a]

		Estimated Harvest of Spiridon Lake Sockeye Salmon											
	Catch	Uganik (253-11-35)			Uyak (254-10-40)			SBTHA (254-50)			Total		
Week	**Date**	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**
28	05-11 Jul	0	0		0	0		0	0		0	0	0
29	12-18 Jul	0	0	5,335	0	0	1,488	0	0		0	0	6,823
30	19-25 Jul	545	705	7,073	1,692	3,286	1,443	0	1,757		2,237	5,748	8,516
31	26 Jul-01 Aug	3,058	6,229	25,547	2,815	6,037	8,742	0	3,178	27,066	5,873	15,444	61,355
32	02-8 Aug	22,153	3,500	59,328	8,356	8,336	7,776	310	2,663	34,309	30,819	14,499	101,413
33	09-15 Aug	0	3,743	16,612	0	4,819	11,850	78,346	10,600	42,586	78,346	19,163	19,164
34	16-22 Aug	11,353	8,523	15,057	19,608	3,701	16,282	13,807	6,914	45,242	44,768	19,138	76,581
35	23-29 Aug	26,606	10,911	14,711	44,645	2,242	15,088	9,947	3,970	9,923	81,198	17,122	17,123
36	30 Aug-05 Sept	4,611	1,598	9,629	627	1,384	0	13,200	2,461	2,648	18,438	5,443	12,277
37	06-12 Sept	0	0	0	0	0	0	0	149	344	0	149	344
Total		**68,326**	**35,209**	**153,292**	**77,743**	**29,805**	**62,670**	**115,610**	**31,692**	**162,118**	**261,679**	**96,706**	**378,080**
Percent		**26%**	**36%**	**41%**	**30%**	**31%**	**17%**	**44%**	**33%**	**43%**	**100%**	**100%**	**100%**

[a] Refer to Figures 2,3, and 4 for location of statistical areas; data from Nelson and Barrett (1994); Nelson and Swanton (1996); Nelson and Swanton (1997).

Table 17. Summary of Spiridon Lake sockeye salmon production, 1991-1996.

Fry Stocking Year	Fry Stocked (millions)	Date Stocked	Stocking Size (g)	Smolt Produced (millions)	Fry to Smolt Surv. (%)	Adult Return [b]	Smolt to Adult Survival (%)	Fry to Adult Survival (%)
1991	3.5	7/5/08	0.23	1.587	45.3	275,500	17.4	7.9
1992	2.2	7/5/08	0.2	0.458	20.8	131,300	28.7	6.0
1993	4.2	6/3/15	0.25	0.856	20.4	339,600	39.7	8.1
1994 [a]	5.7	5/18-6/8	0.18	0.613	10.8	7,000	[c]	[c]
1995 [a]	4.6	6/14-7/11	0.35	0.803	17.5	0	[c]	[c]
1996 [a]	4.8	5/21-6/26	0.3	[c]	[c]	[c]	[c]	[c]

[a] Smolt outmigration incomplete for some age classes.

[b] Additional returns expected from all stocking years.

[c] Not applicable

Table 18. Peak index salmon escapements and commercial catches in Spiridon River, Spiridon Bay, Telrod Creek, and Telrod Cove (SBTHA), 1980 - 1996.

	Spiridon River (254-401)			Spiridon Bay (254-40)			Telrod Creek[a] (254-501)		Telrod Cove (254-50)			
	Escapement			Commercial Catch[b]			Escapement		Commercial Catch[b]			
Year	Pink	Chum	Coho	Pink	Chum	Coho	Pink	Sockeye	Pink	Chum	Coho	Sockeye[c]
1980	35,000	12,600	-	131,162	2,037	2,625	-					
1981	-	7,000	-	109,470	4,012	4,526	50					
1982	7,000	38,000	8,000	69,796	28,138	2,097	-					
1983	30,000	40,000	-	85,920	11,606	1,457	20					
1984	4,000	21,000	6,700	423,572	19,308	4,487	200					
1985	-	-	-	112,808	11,928	2,358	-					
1986	44,000	67,000	6,300	550,174	38,566	4,611	-					
1987	-	-	3,900	78,233	22,275	6,221	-					
1988	-	15,000	-	1,365,927	48,717	13,831	-					
1989	48,000	32,000	-	-	-	-	100					
1990	38,000	2,050	17,325	169,457	15,101	10,743	-					
1991	86,000	39,000	8,975	326,591	24,732	9,909	-					
1992	18,200	16,900	3,570	142,251	35,468	7,546	-					
1993	34,000	5,000	2,250	710,435	20,335	7,575	5,000[b]	3,500				
1994	12,800	10,300	4,800	334,031	24,824	7,875	475	3,500	30,337	297	2,590	115,823
1995	69,800	22,000	10,300	2,066,632	80,946	10,556	233	12	100,426[d]	8,474[d]	139[c]	31,692
1996	5,700	8,000	10,600	88,656	14,566	4,573	238	10	42,705	2,688	1,626	162,118
Average 1980-96:	33,269	22,390	7,520	422,820	25,160	6,312	188					
Minimum Escapement Goal:	15,000	15,000	4,000				100	[e]				

[a] The survey estimate in 1993 was a combined total of Telrod Cove and Telrod Creek; Telrod Creek estimates were foot surveys for all years.

[b] Refer to Figure 4 for Statistical Areas; from ADF&G fish ticket summaries unless otherwise noted; prior to 1994, (254-50) was closed to commercial fishing.

[c] From Nelson and Barrett (1994); Nelson and Swanton (1996); Nelson and Swanton (1997); indicate Spiridon Lake origin catch, only.

[d] Telrod Cove (254-50) commercial catch totals included on-site estimates made during the 1995 season.

[e] No escapement goal is established for sockeye salmon at Telrod Creek.

Source: ADF&G Database, and Kodiak Area Annual Management Reports.

Table 19. Spiridon Bay Terminal Harvest Area (254-50) weekly catches by species, 1994 - 1996.[a]

	Sockeye			Chinook			Coho			Pink			Chum		
Dates	1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996
July 19-July 25	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
July 26-Aug. 01	[b]	0	27,066	0	0	6	0	0	44	1,363	0	12,740	0	0	1,448
Aug. 02-Aug. 08	312	580	34,309	0	0	5	0	4	96	404	4,710	10,329	10	107	1,044
Aug. 09-Aug. 15	78,424	2,347	42,586	0	0	7	120	37	151	18,114	17,190	8,349	216	49	81
Aug. 16-Aug. 22	13,890	4,753	45,242	0	0	18	349	119	485	7,087	20,364	7,645	10	18	84
Aug. 23-Aug. 29	9,997	1,806	9,923	0	0	3	424	28	620	2,758	1,688	3,031	12	0	28
Aug. 30-Sep. 05	13,514	259	2,648	0	0	0	854	4	220	611	256	561	8	0	2
Sep. 06-Sep. 12	6,402	149	344	0	0	0	116	7	10	0	219	50	3	0	1
Sep. 13-Sep.19	4,878	0	0	0	0	0	718	0	0	0	0	0	38	0	0
Sep. 20-Sep.26	988	0	0	0	0	0	9	0	0	0	0	0	0	0	0
TOTAL	128,405	31,692	162,118	0	0	39	2,590	139	1,626	30,337	100,426	42,705	297	8,474	2,688

[a] Total catch information obtained from ADF&G Fish Ticket Database except for 1995 totals consisted of on-site estimates obtained from P. Nelson, ADF&G, Kodiak, personal communication.

[b] No fishery.

Table 20. Incidence of Infectious Hematopoietic Necrosis Virus (IHNV) in chum salmon samples collected from Kodiak and Afognak Island systems, 1982 - 1995.

Year Sampled	Source	IHNV Number	IHNV Percent	Location
1982	Sturgeon River	0/60	0%	Kodiak Island
1983	Sturgeon River	0/38	0%	Kodiak Island
1984	Sturgeon River	0/50	0%	Kodiak Island
1985	Sturgeon River	0/56	0%	Kodiak Island
1986	Big Kitoi	0/50	0%	Afognak Island
1988	Big Kitoi	0/60	0%	Afognak Island
1989	Big Kitoi	0/60	0%	Afognak Island
1990	Big Kitoi	0/60	0%	Afognak Island
1991	Big Kitoi	0/150	0%	Afognak Island
1992	Big Kitoi	0/60	0%	Afognak Island
1993	Big Kitoi	0/60	0%	Afognak Island
1994	Big Kitoi	0/60	0%	Afognak Island
1995	Big Kitoi	0/33	0%	Afognak Island
1995	Spiridon River	0/39	0%	Kodiak Island

Table 21. Allele frequencies for upper Upper Station, lower Upper Station, and Saltery Creek, 1993 and 1994.[a]

Population	sAAT-1,2		sAAT-3		mAAT-1			mAAT-2		
	N	100	N	100	N	-100	-83	N	-100	-191
Upper Upper Station	100	1	99	1	88	0.972	0.028	94	1	0
Lower Upper Station	100	1	100	1	99	0.823	0.177	98	1	0
Saltery Creek	99	1	99	1	97	0.918	0.082	100	0.965	0.035

Population	mAH-1,2			mAH- 4		sAH			ALAT		
	N	100	75	N	100	N	100	83	N	100	91
Upper Upper Station	42	0.958	0.042	46	1	98	0.99	0.01	89	0.697	0.303
Lower Upper Station	95	0.905	0.095	100	1	100	1	0	99	0.682	0.318
Saltery Creek	98	0.977	0.023	99	1	100	1	0	99	0.798	0.202

Population	CK- A2		CK- B			FDH		GAPDH-2		
	N	100	N	100	102	N	100	N	100	208
Upper Upper Station						100	1	99	1	0
Lower Upper Station	100	1	100	0.985	0.015	100	1	100	1	0
Saltery Creek	100	1	100	1	0	100	1	100	0.995	0.005

Population	G3PDH-1,2		G3PDH 4		GPI B1,2		GPI- A		mIDHP -1	
	N	-100	N	100	N	100	N	100	N	100
Upper Upper Station	92	1	99	1	95	1	95	1	100	1
Lower Upper Station	100	1	100	1	100	1	100	1	96	1
Saltery Creek	100	1	100	1	100	1	100	1	100	1

Population	sIDHP-1		sIDHP- 2		LDH-A2		LDH-B2			sMDH A1,2	
	N	100	N	100	N	100	N	100	110	N	100
Upper Upper Station	97	1	97	1	93	1	100	0.94	0.06	97	1
Lower Upper Station					95	1	100	0.93	0.07	100	1
Saltery Creek	100	1	100	1	100	1	100	0.89	0.11	100	1

Population	sMDH-B1,2		mMEP-1			MPI		PEPA		PEPB- 1	
	N	100	N	100	58	N	100	N	100	N	100
Upper Upper Station	100	1	96	1	0	100	1	100	1	96	1
Lower Upper Station	100	1	100	1	0	100	1	100	1	100	1
Saltery Creek	100	1	100	0.99	0.01	100	1	100	1	100	1

-Continued-

Table 21. (page 2 of 2)

Population	PEPC			PEPD-1		PEPLT		PGDH	
	N	100	105	N	100	N	100	N	100
Upper Upper Station	95	0.995	0.005	94	1	95	1	97	1
Lower Upper Station	99	0.97	0.03	100	1	100	1	100	1
Saltery Creek	99	0.99	0.01	100	1	100	1	100	1

Population	PGM- 1			PGM-2			sSOD-1		TPI-1,2		
	N	100	null	N	100	136	N	100	N	-100	-173
Upper Upper Station	94	0.021	0.979	98	0.755	0.245	100	1	100	0.995	0.005
Lower Upper Station	100	0.03	0.97	100	0.81	0.19	98	1	100	0.992	0.008
Saltery Creek	99	0.343	0.657	100	0.67	0.33	99	1	100	1	0

Population	TP-3			TPI-4	
	N	100	98	N	100
Upper Upper Station	100	1	0	100	1
Lower Upper Station	100	1	0	100	1
Saltery Creek	100	0.965	0.035	100	1

[a] Data provided by C. Habicht, ADF&G, Anchorage, personal communication.

Table 22. G--Statistics for pair-wise comparisons for upper and lower Upper Station Lakes (1993) and Saltery Lake (1994) sockeye salmon.[a]

Locus	G Statistic	DF	P Value
Upper Upper Station - Lower Upper Station			
mAAT1	24.21	1	0
mAH1,2	5.06	1	0.02
sAH	2.82	1	0.09
ALAT	0.1	1	0.75
LDHB2	0.16	1	0.68
PEPC	3.82	1	0.05
PGM1	0.3	1	0.58
PGM2	1.76	1	0.18
TPI1,2	0.2	1	0.65
Total	38.43	9	0
Lower Upper Station - Saltery Creek			
mAAT1	7.87	1	0
mAAT2	9.69	1	0
mAH1,2	19.25	1	0
ALAT	6.99	1	0
CKB	4.18	1	0.04
GAPDH2	1.39	1	0.23
LDHB2	1.97	1	0.16
mMEP1	2.78	1	0.09
PEPC	2.13	1	0.14
PGM1	73.65	1	0
PGM2	10.28	1	0
TPI1,2	4.17	1	0.04
TPI3	9.83	1	0
Total	154.19	13	0
Upper Upper Station - Saltery Creek			
mAAT1	5.32	1	0.02
mAAT2	9.4	1	0
mAH1,2	1.39	1	0.23
sAH	2.82	1	0.09
ALAT	5.14	1	0.02
GAPDH2	1.38	1	0.24
LDHB2	3.26	1	0.07
mMEP1	2.7	1	0.1
PEPC	0.3	1	0.58
PGM1	77.99	1	0
PGM2	3.51	1	0.06
TPI1,2	2.78	1	0.09
TPI3	9.83	1	0
Total	125.82	13	0

[a] Data provided by C. Habicht, ADF&G, Anchorage, personal communication.

Table 23. Hardy-Weinberg test results: genetic samples from Upper Station (1993) and Saltery (1994) Lakes sockeye salmon.[a]

Locus	G Statistic	DF	P Value
Upper Upper Station			
mAAT1	0.14	1	0.7022
mAH1,2	0.94	3	0.8154
sAH	11.2	1	0.0008
ALAT	0	1	0.9236
LDHB2	0.76	1	0.3813
PEPC	0	1	0.942
PGM2	0.23	1	0.6274
TPI1,2	0.03	3	0.9986
Overall	13.3	12	0.3480
Lower Upper Station			
mAAT1	7.57	1	0.0059
mAH1,2	3.14	3	0.3713
ALAT	0.2	1	0.6521
CKB	0.04	1	0.8307
LDHB2	1.06	1	0.3044
PEPC	0.18	1	0.665
PGM2	0.06	1	0.8019
TPI1,2	0.06	3	0.9953
Overall	12.3	12	0.4194
Saltery Lake			
mAAT1	1.4	1	0.2301
mAAT2	0.25	1	0.6143
mAH1,2	0.64	3	0.8861
ALAT	1.4	1	0.2387
GAPDH2	0.01	1	0.9435
LDHB2	0.57	1	0.4506
mMEP1	0.02	1	0.887
PEPC	0.02	1	0.8864
PGM2	0.9	1	0.3432
TPI3	0.25	1	0.6143
Overall	5.5	12	0.9394

[a] Data provided by C. Habicht, ADF&G, Anchorage, personal communication.

Table 24. Saltery Lake sockeye salmon cumulative escapement, 1987-1996.

Year	Weir Operation Dates	Escapement Count
1987	6/17-10/1	22,705
1988	6/17-9/11	25,654
1989	6/11-9/25	30,237
1990	6/10-9/16	29,767
1991	6/12-9/5	52,592
1992	6/14-6/30	44,450 [a]
1993	6/22-8/9	77,186
1994	6/20-9/21	58,975
1995	6/22-8/11	43,859
1996	6/22-8/9	35,488
Average 1987-96:		42,091

[a] Peak aerial survey estimate; remainder of data from Brodie (1996).

Table 25. Saltery Lake sockeye salmon weekly escapement, proportions weighted by tagging period and proportions observed at spawning areas, 1994.

Date		Weekly Escapement			Spawning Areas		
Calendar	Period	Number	Percent	Weighted	M.E.Crk [a]	East Creek	Lake Shoals
20 - 26 Jun	1	708	1.2%	NA	NA	NA	NA
27 May - 3 July	2	4,154	7.3%	NA	NA	NA	NA
04 - 10 July	3	3,500	6.2%	NA	NA	NA	NA
11 - 17 July	4	11,181	19.7%	NA	NA	NA	NA
18 - 24 July	5	11,776	20.7%	33.1%	30.7%	36.6%	49.1%
25 - 31 July	6	11,122	19.6%	31.3%	27.4%	38.8%	30.9%
01 - 07 August	7	7,551	13.3%	21.2%	30.0%	16.9%	10.6%
08 - 14 August	8	5,087	8.9%	14.3%	11.8%	7.7%	9.4%
15 - 21 August	9	1,807	3.2%	NA	NA	NA	NA
	Totals	56,886	100.0%	100.0%	100.0%	100.0%	100.0%

NA = not applicable

[a] Mouth of east creek - brood stock collection area.

Table 26. Saltery Lake sockeye salmon escapement age composition (%), 1985-1996.[a]

Year	Sample Size	Ages 1.2	2.2	1.3	2.3	other
1985	305	26.7	0.7	49.0	16.2	0.4
1986	602	2.6	0.4	88.8	5.1	3.1
1987	629	54.1	4.4	36.9	2.7	1.9
1988	477	2.1	7.8	80.9	0.2	0.0
1989	479	10.9	11.5	26.5	50.3	0.8
1993	513	0.8	23.0	10.5	64.7	1.0
1994	485	22.0	6.0	6.0	64.0	2.0
1995	437	1.6	7.3	82.1	7.6	1.4
1996	418	3.0	4.0	30.0	62.0	1.0
	Mean:	13.8	7.2	45.6	30.3	1.3
	Weighted Mean:	14.5	7.4	45.9	29.3	1.4

[a] Data provided by C. Hicks, ADF&G, Kodiak, personal communication.

Table 27. Number sampled and incidence of IHNV from Kodiak and Afognak area sockeye salmon stocks, 1987-1996.

Year		IHNV		
Sampled	Source	Number	Percent	Comments
1987	Afognak	3/59	5%	
1988	Afognak	0/60	0%	
1993	Afognak	0/60	0%	
1990	Malina	0/62	0%	
1993	Malina	0/51	0%	
1993	Paul's	26/60	43%	
1988	Sitkalidak	0/60	0%	
1991	Rose Tead	0/53	0%	
1991	Frazer	44/60	73%	
1992	Little Kitoi	24/62	39%	
1993	Little Kitoi	43/64	67%	
1992	Karluk	58/60	97%	
1987	Upper Station	12/58	21%	
1988	Upper Station	28/60	47%	
1989	Upper Station	46/63	73%	
1993	Upper Station	31/56	55%	upper lake
1993	Upper Station	24/59	41%	lower lake
1986	Saltery	20/60	34%	
1994	Saltery	55/60	92%	
1995	Saltery	13/39	33%	
1996	Saltery	47/66	71%	

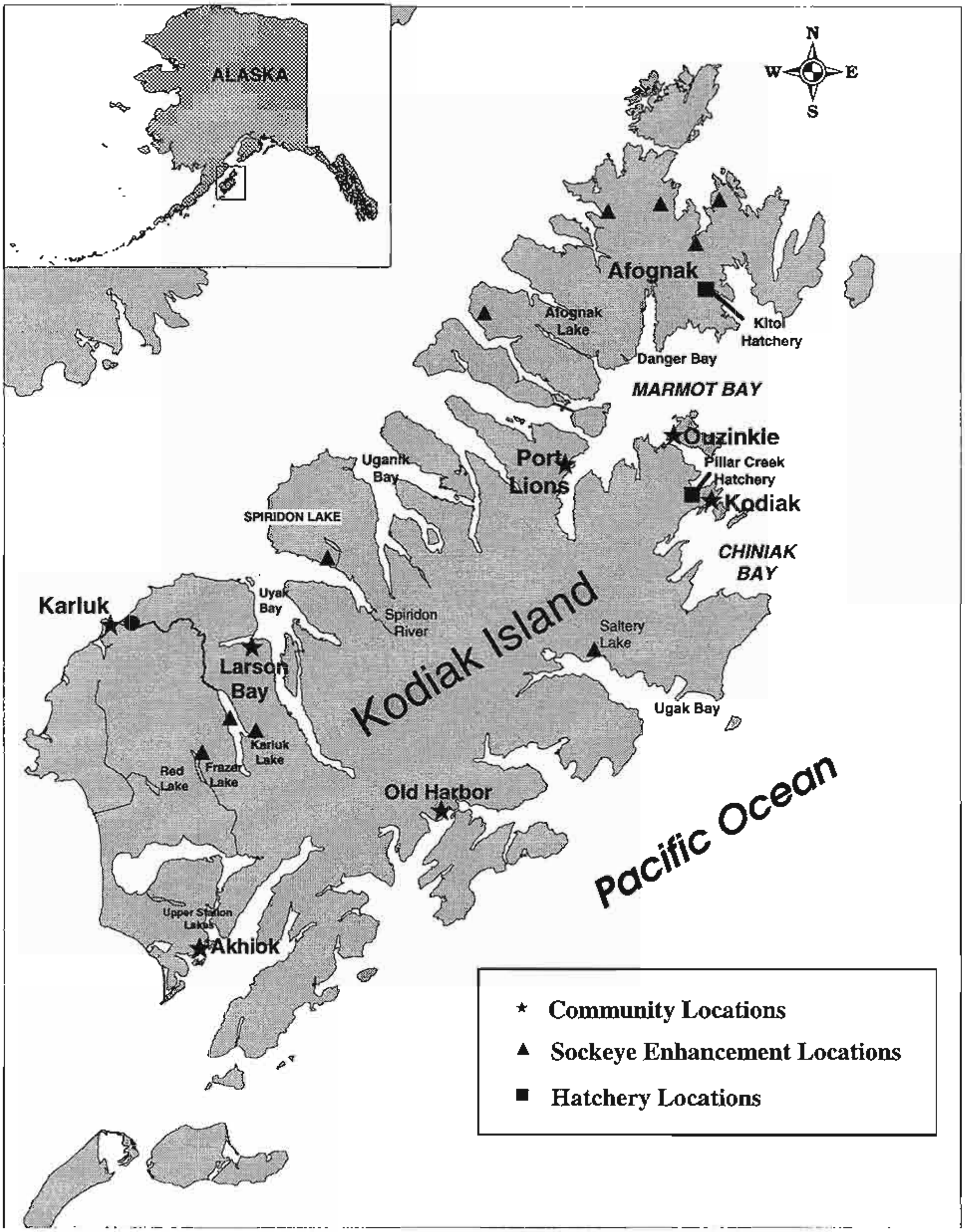


Figure 1. Area map of Kodiak and Afognak Islands showing location of Spiridon Lake, Pillar Creek Hatchery, and brood sources (Upper Station and Saltery Lakes).

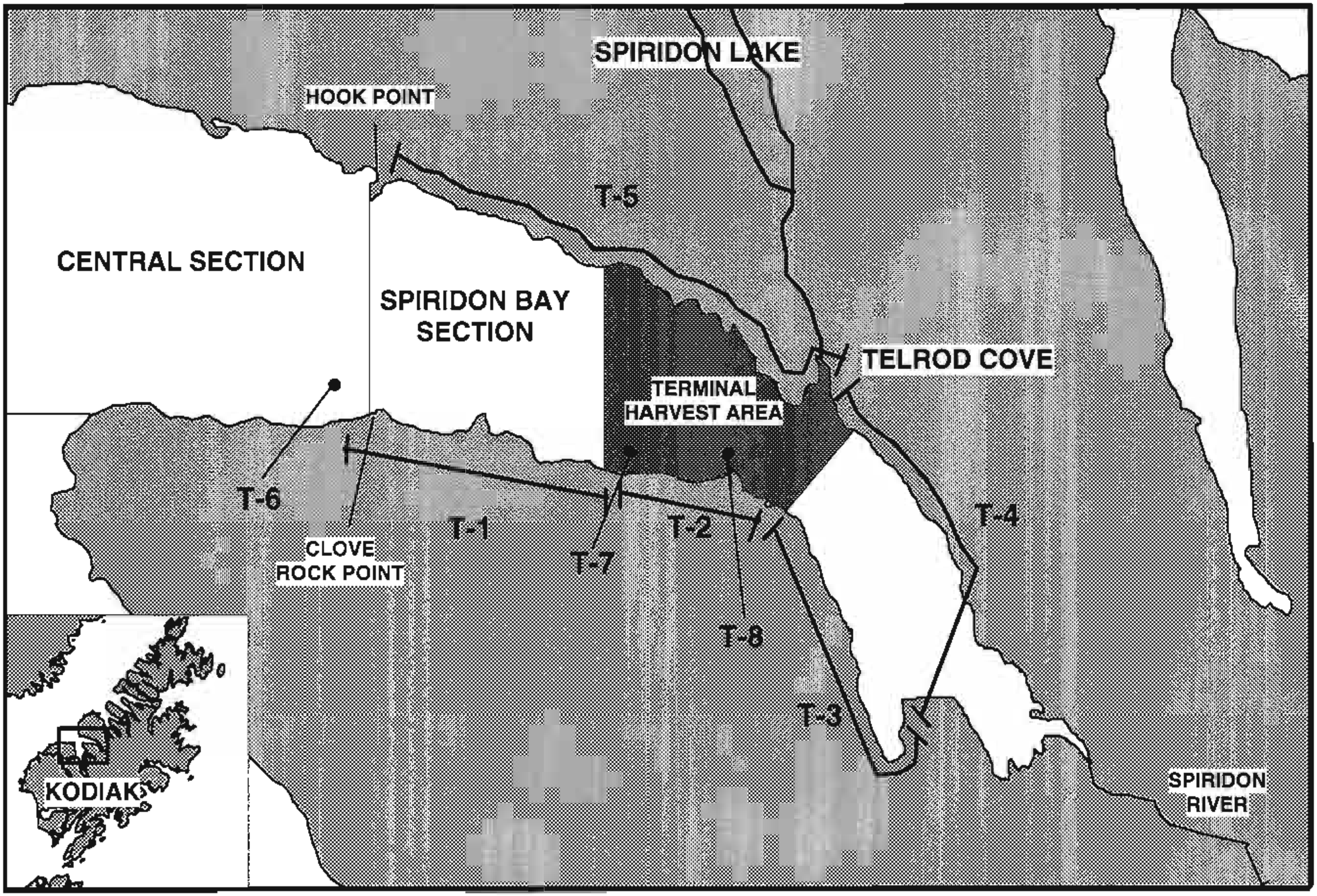


Figure 2. Map identifying the approximate boundaries of the 1994 Spiridon Bay Special Harvest Area and survey transects (T 1-8) depicted in Spiridon Bay to identify and enumerate wildlife.

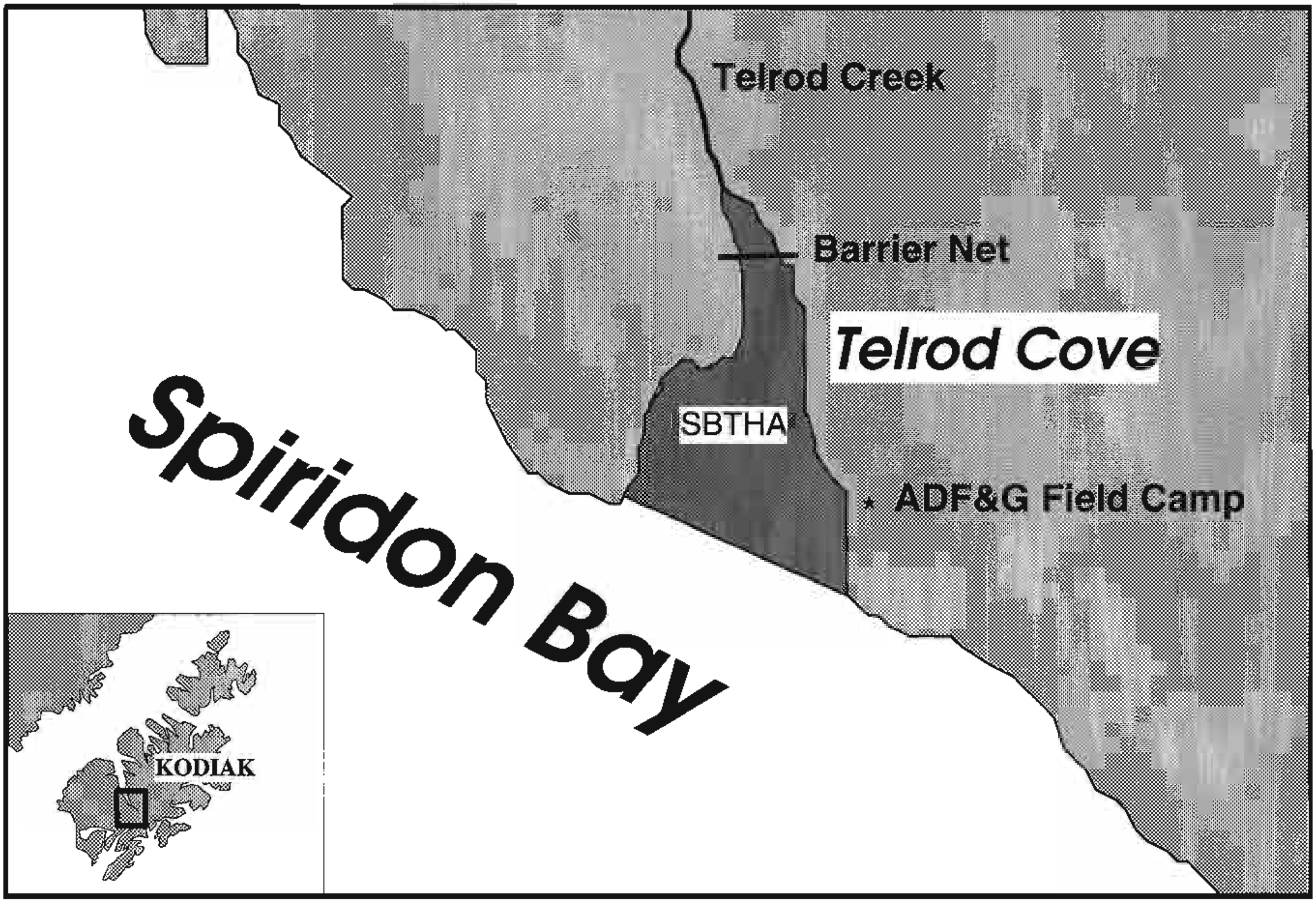


Figure 3. Spiridon Bay Terminal Harvest Area (SBTHA), ADF&G camp and barrier net location in Telrod Cove, 1995 and 1996.

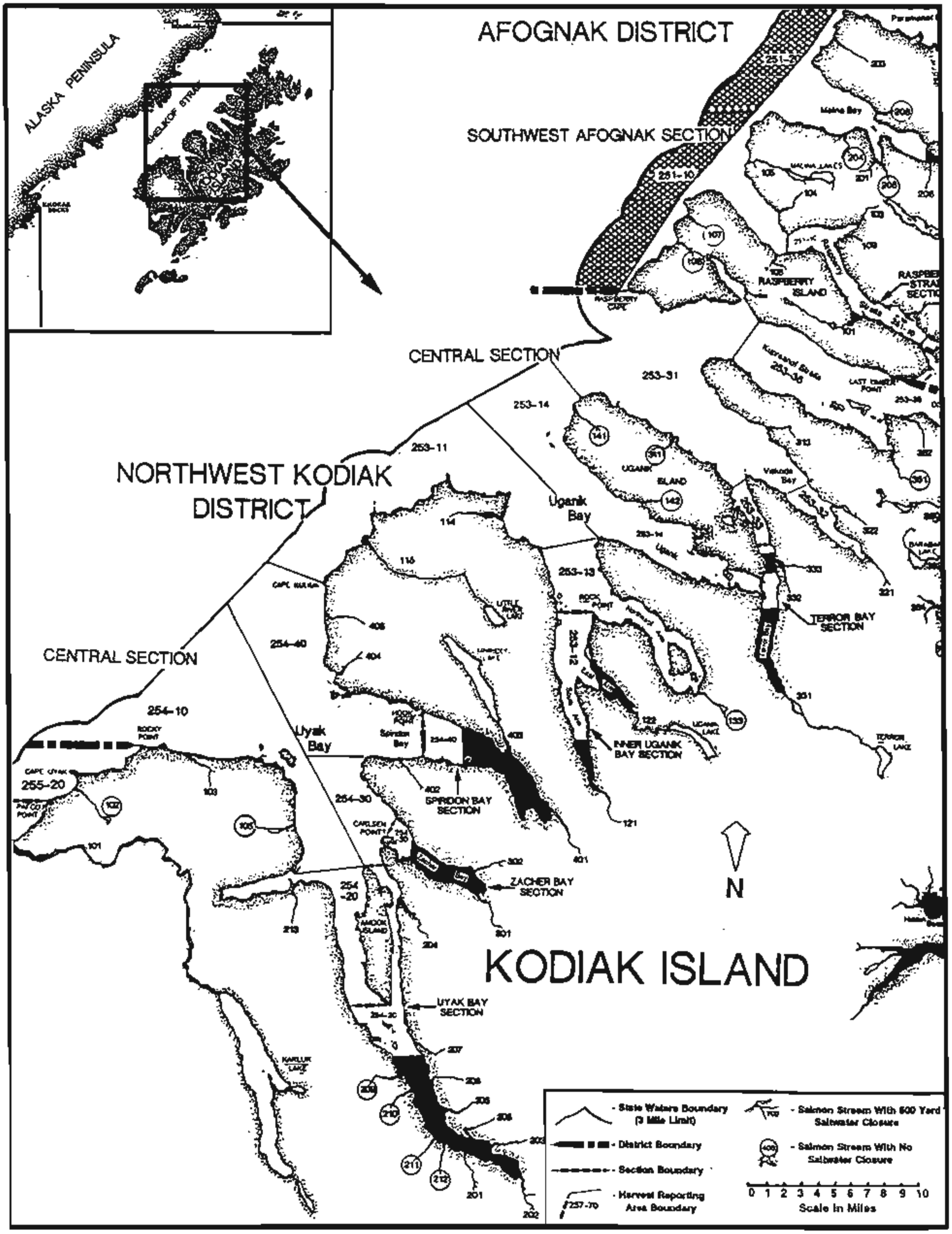


Figure 4. Map of the Northwest Kodiak District of the Kodiak Management Area, and location of Spiridon Lake.

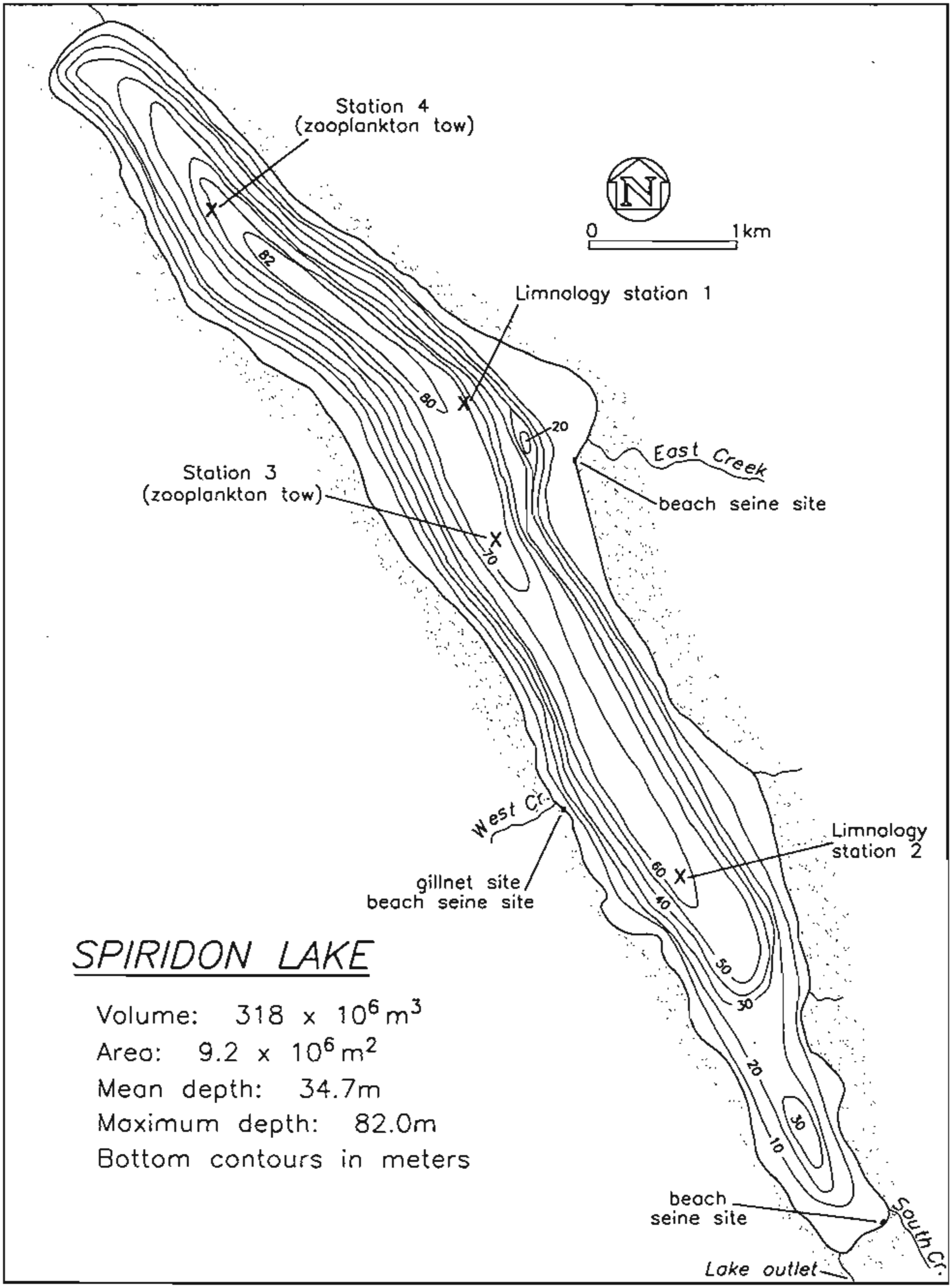


Figure 5. Morphometric map showing limnology and zooplankton stations (1–4), and beach seine and gillnet sites on Spiridon Lake.

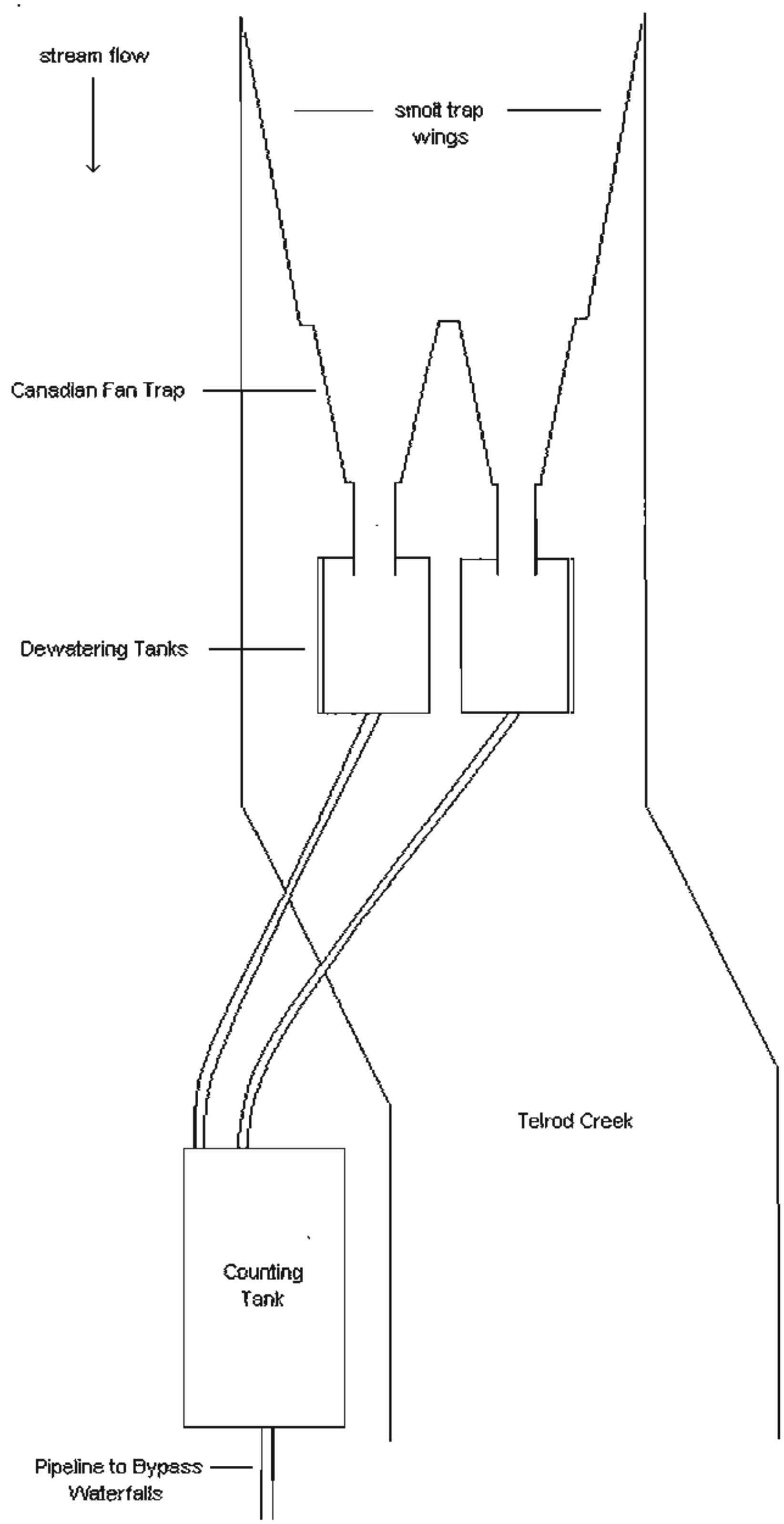


Figure 6. Diagram of the sockeye smolt bypass system on the outlet creek of Spiridon Lake.

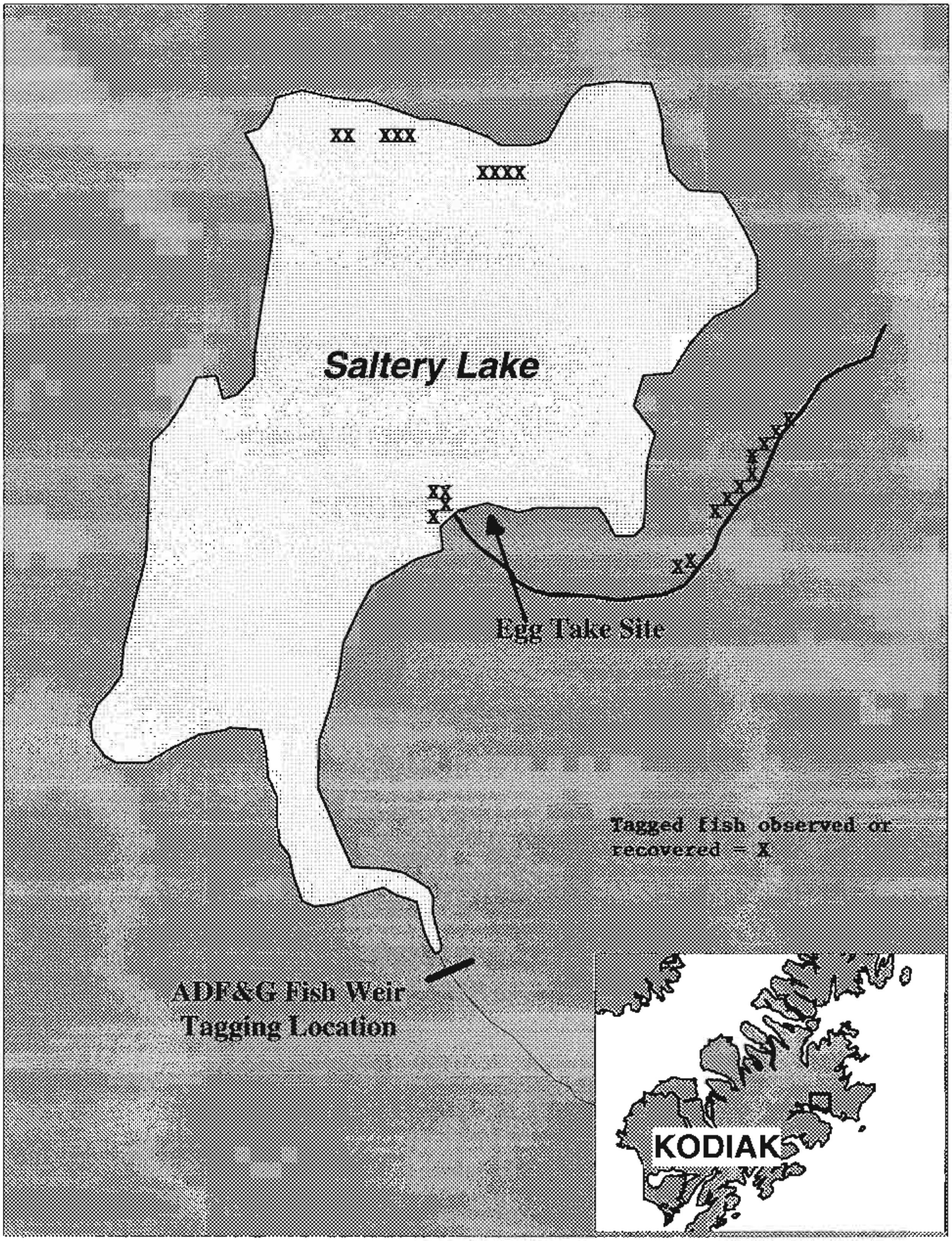


Figure 7. The location of the ADF&G weir (tagging site), tagged fish observed, and egg take site at Saltery Lake, Kodiak Island.

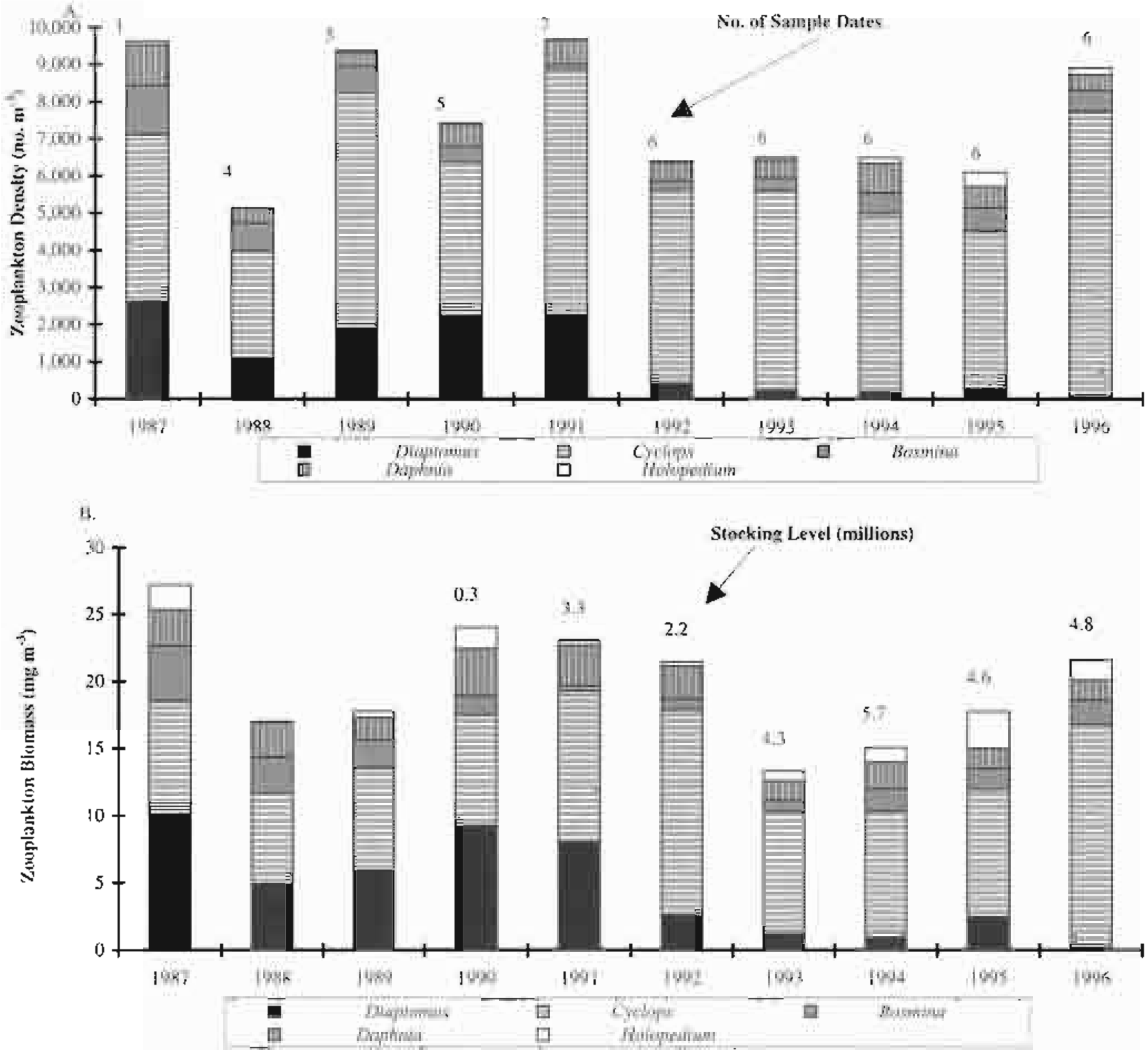


Figure 8. Zooplankton density (A) and biomass (B) for Spiridon Lake, 1987-1996

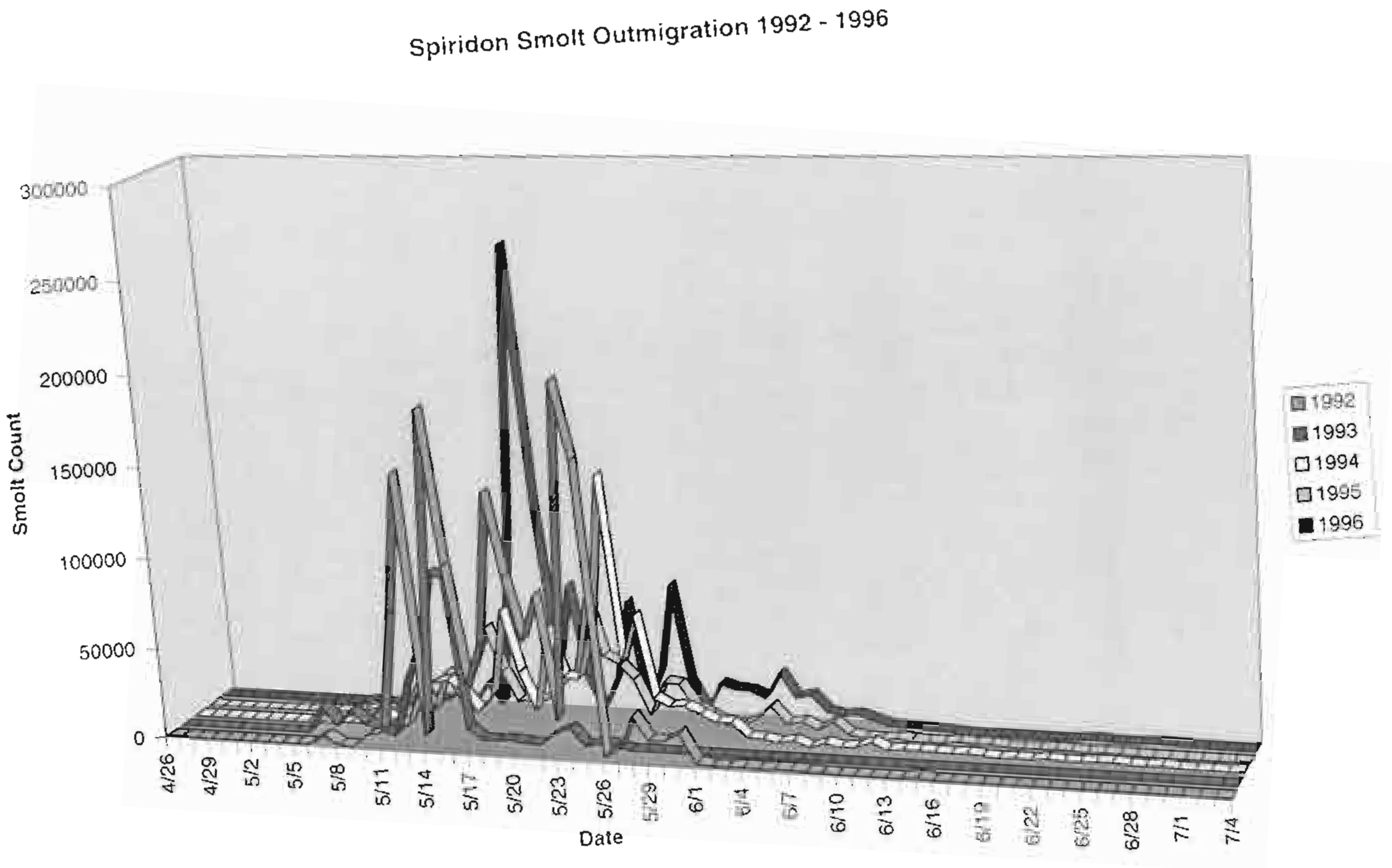


Figure 9. Spiridon Lake sockeye salmon smolt migration timing, 1992-1996.

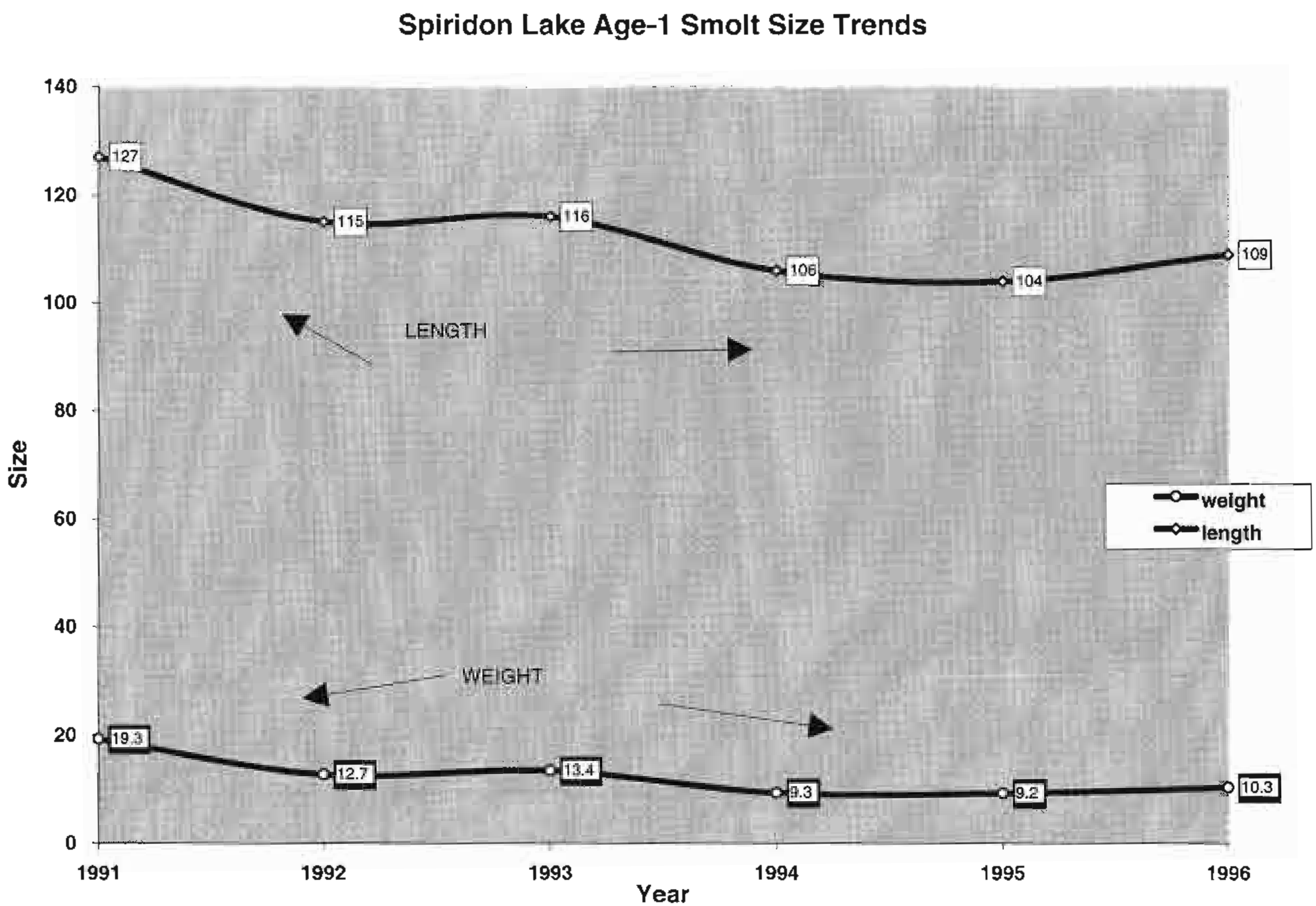


Figure 10. Spiridon Lake sockeye salmon smolt age-1 weight(g) and length(mm), 1991-1996.

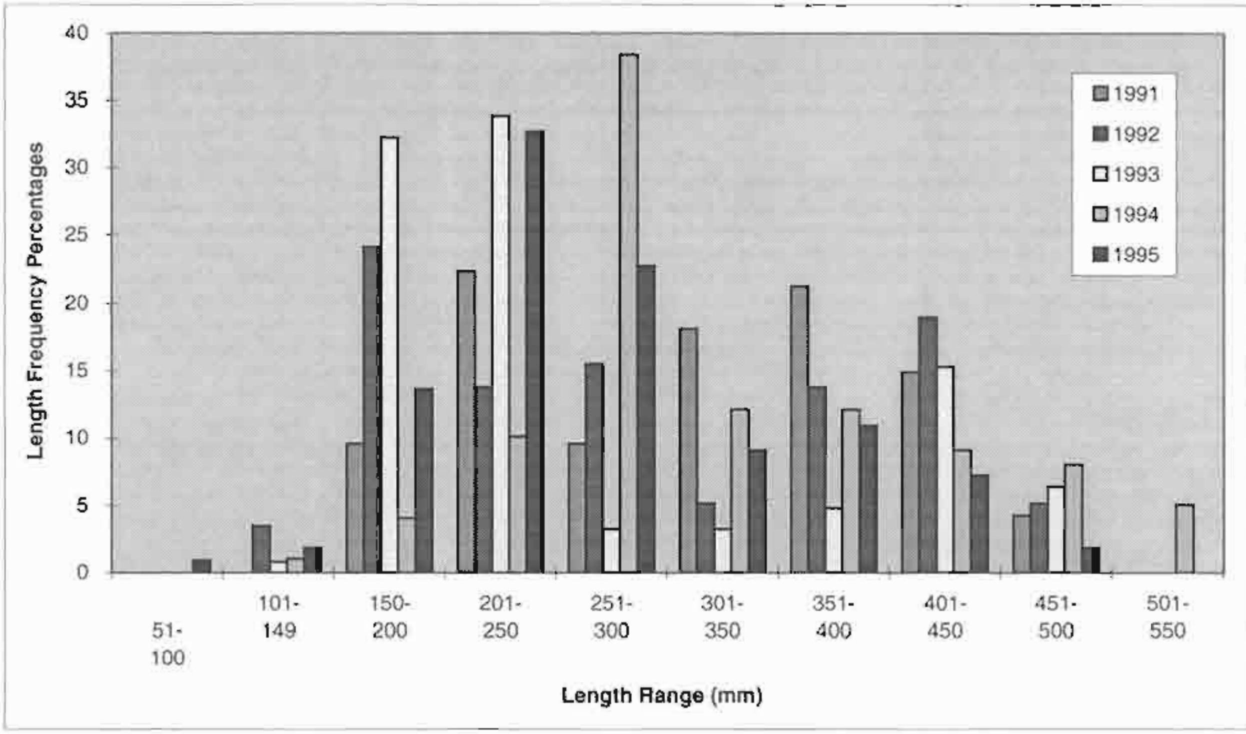


Figure 11. Spiridon Lake Dolly Varden gillnet survey length frequency information, 1991 - 1995.

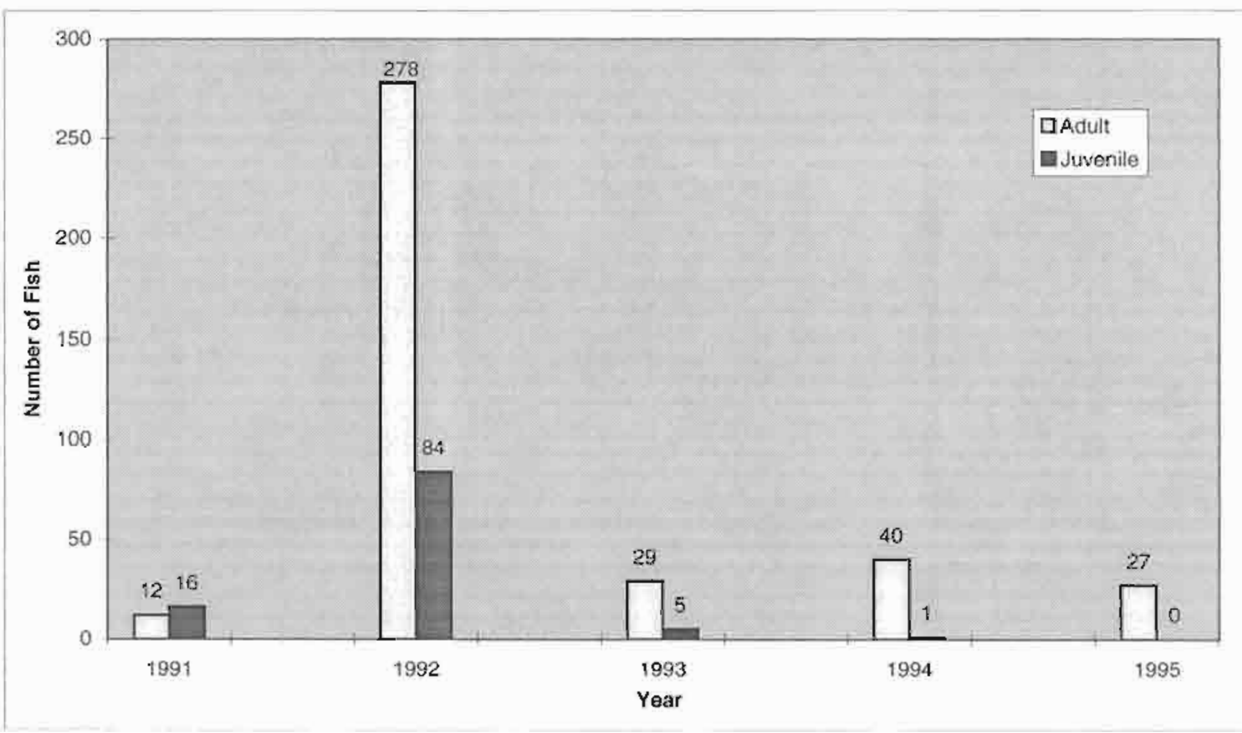


Figure 12. Adult and juvenile Dolly Varden caught beach seining in Spiridon Lake, 1991 - 1995.

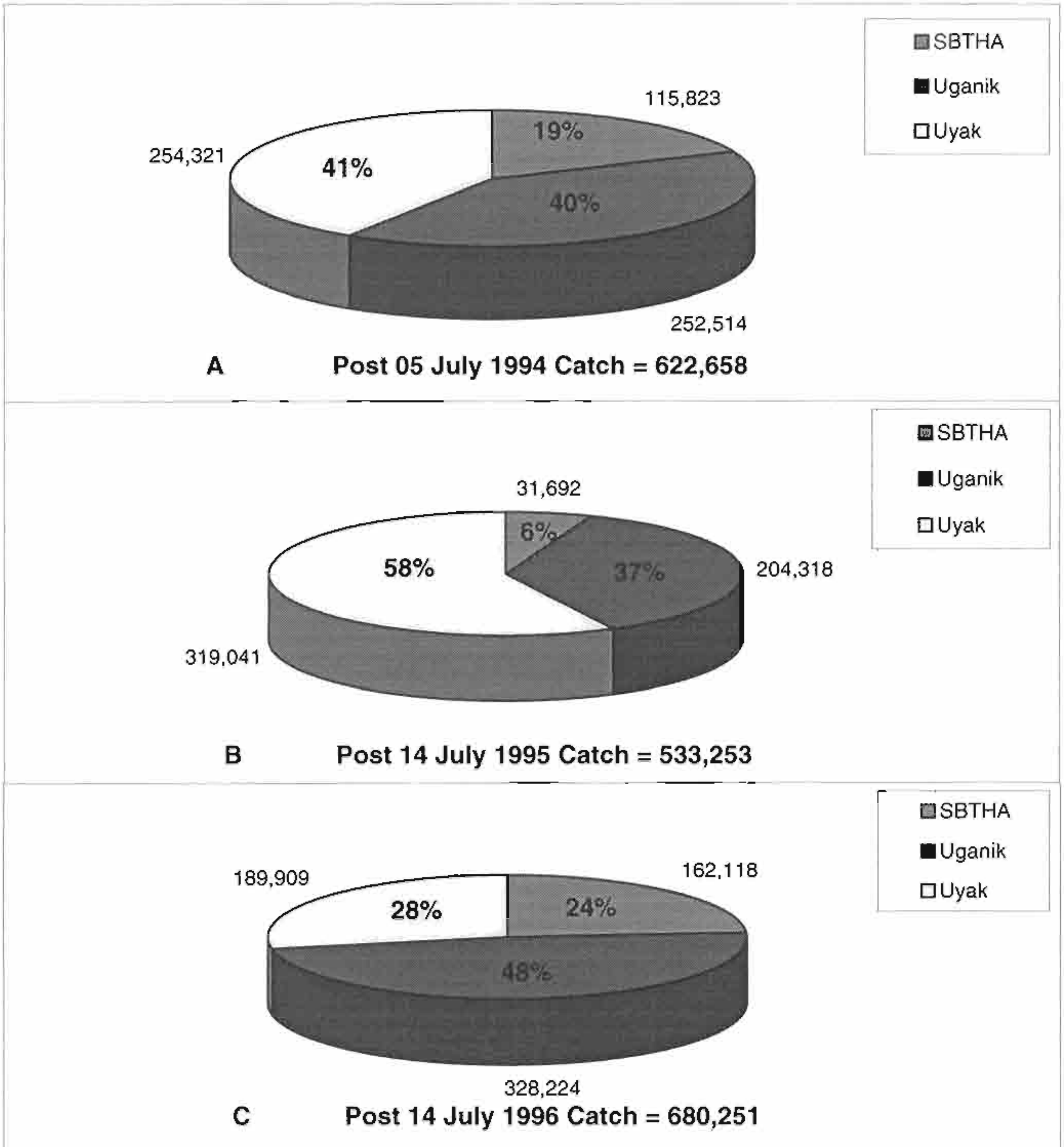


Figure 13. NW Kodiak District estimated sockeye catch, 1994(A), 1995(B), and 1996(C); data from C.Hicks, ADF&G, Kodiak, personal communication.

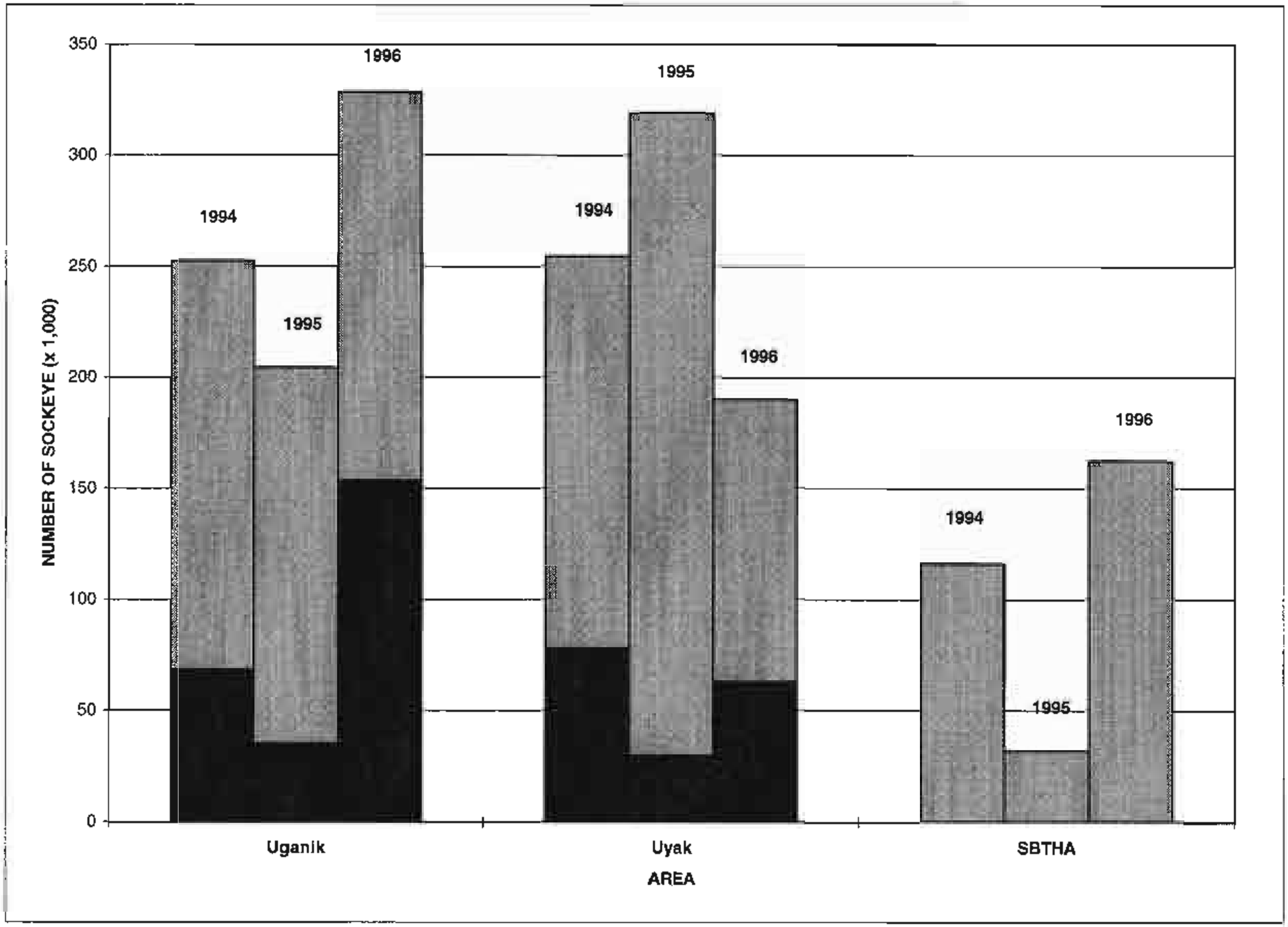


Figure 14. Total sockeye harvest (total bar height) compared to contribution of Spiridon Lake sockeye (dark), by area, 1994-1996. The total harvest for the SBTHA was composed of Spiridon Lake sockeye.

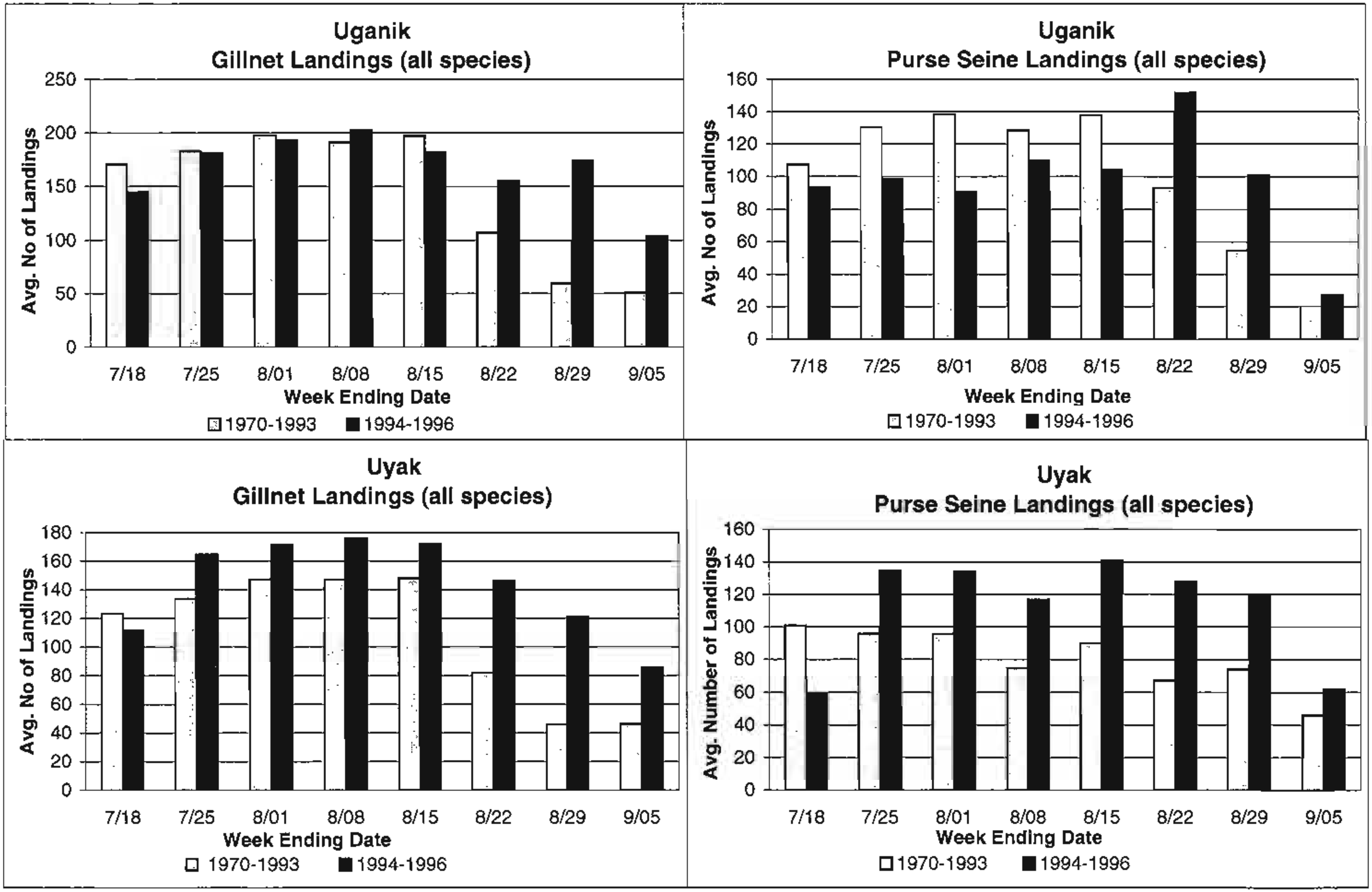


Figure 15. A comparison of average purse seine and gillnet landings (all species) by week for Uganik (253-11 through 253-33) and Uyak Bay (254-10 through 254-40), July 12 through September 5.

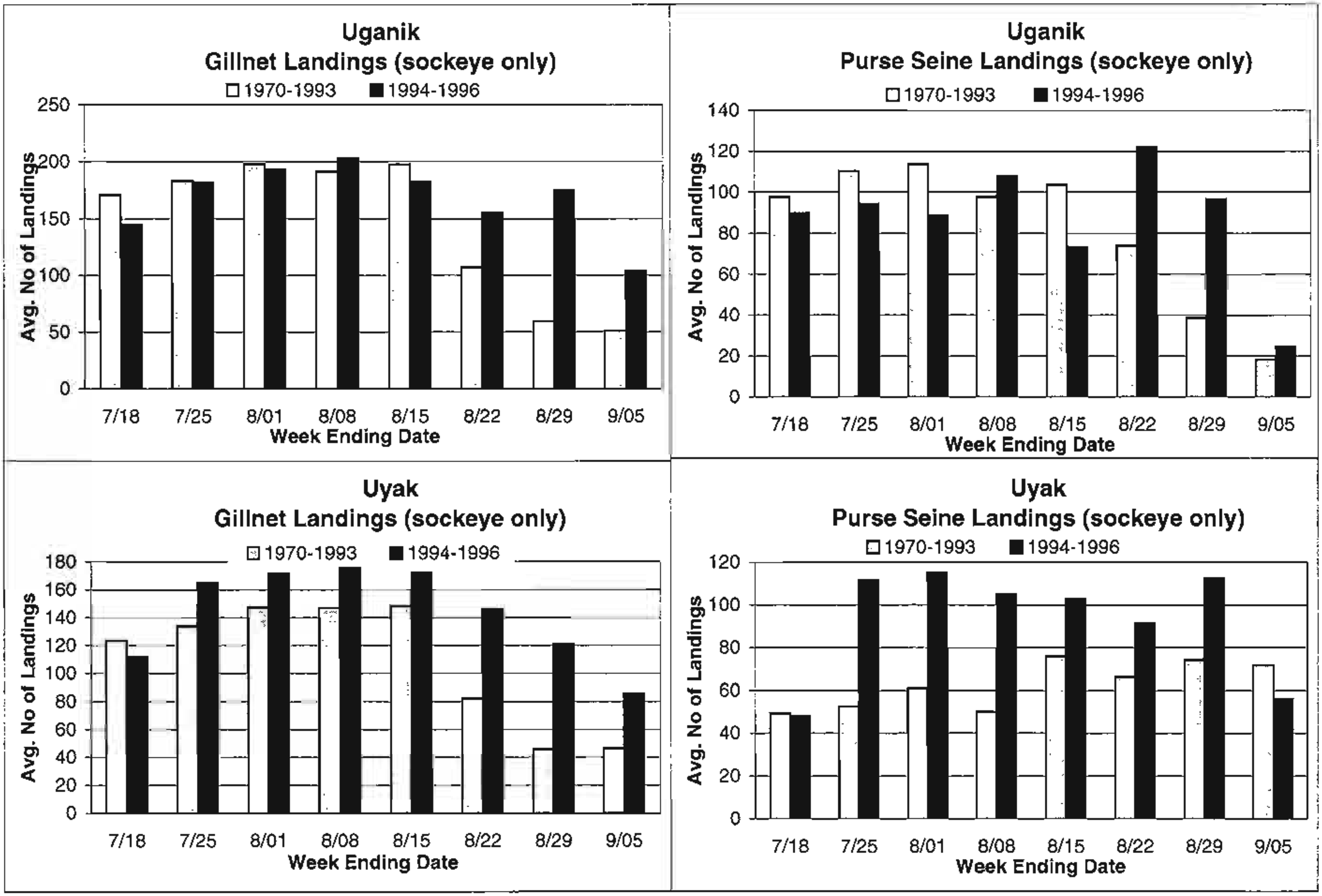


Figure 16. A comparison of average purse seine and gillnet sockeye landings by week, Uganik (253-11 through 253-33) and Uyak Bays (254-10 through 254-40), July 12 - September 5; from C.Hicks, ADF, Kodiak, personal communication.

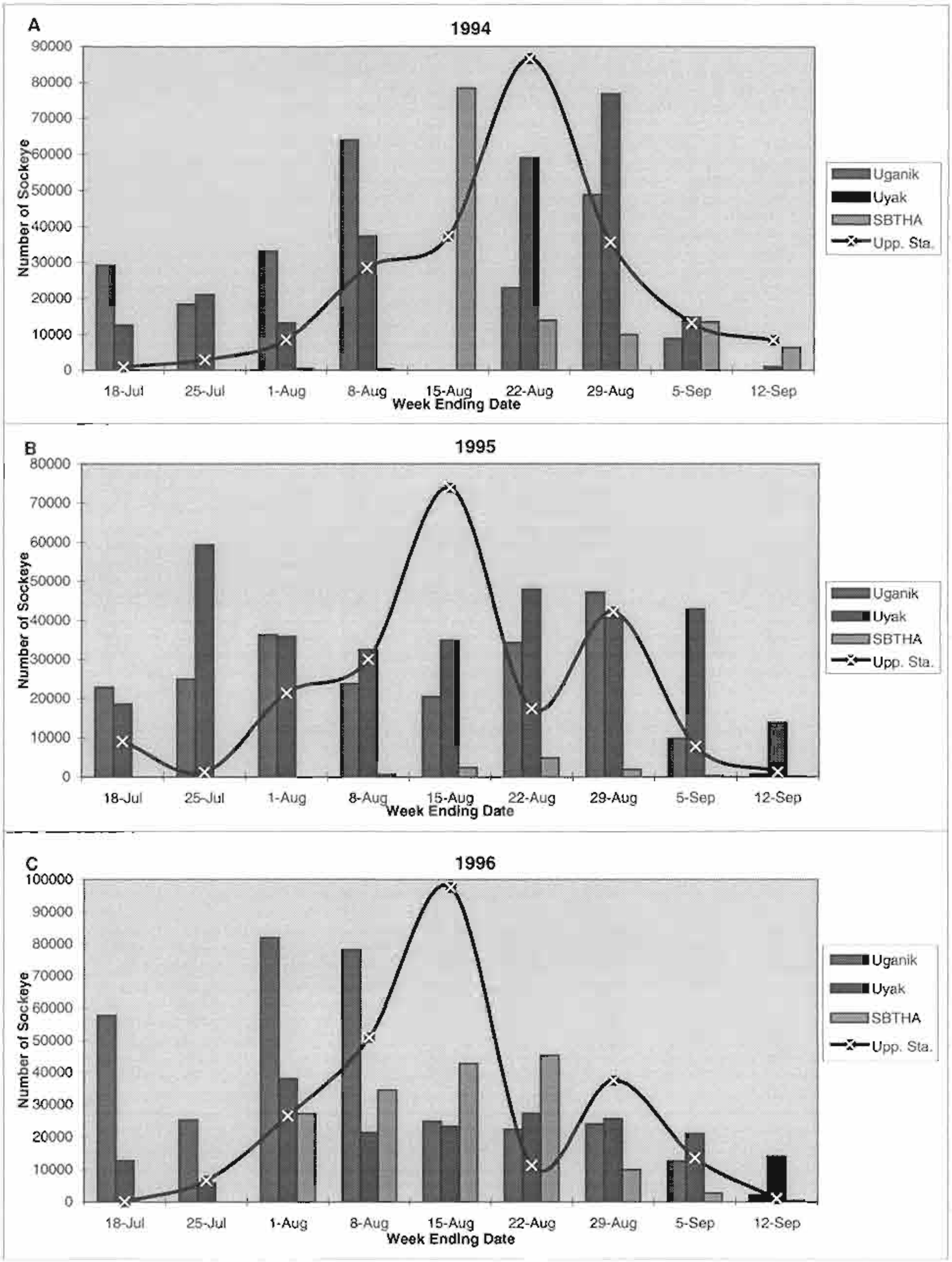


Figure 17. Age-1.2 sockeye catch timing in Uganik, Uyak, and SBTHA, NW Kodiak District and U. Station late run escapement timing, 1994 (A), 1995 (B), and 1996 (C); from C.Hicks, ADF, Kodiak, personal communication.

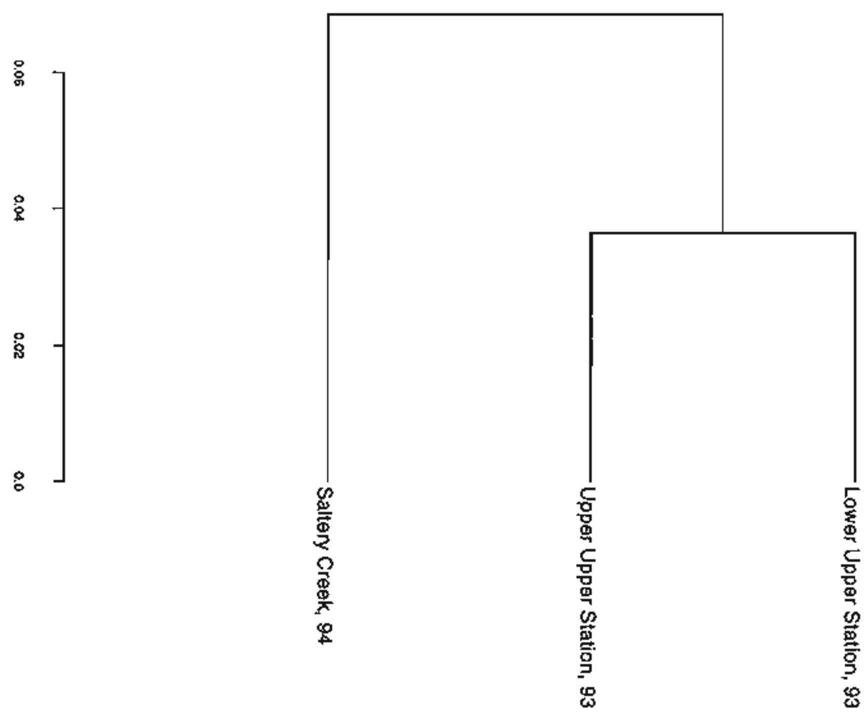


Figure 18. Phenogram of the relationships between upper Upper Station, lower Upper Station, and Saltery Lake collections using Nei's genetic distance.

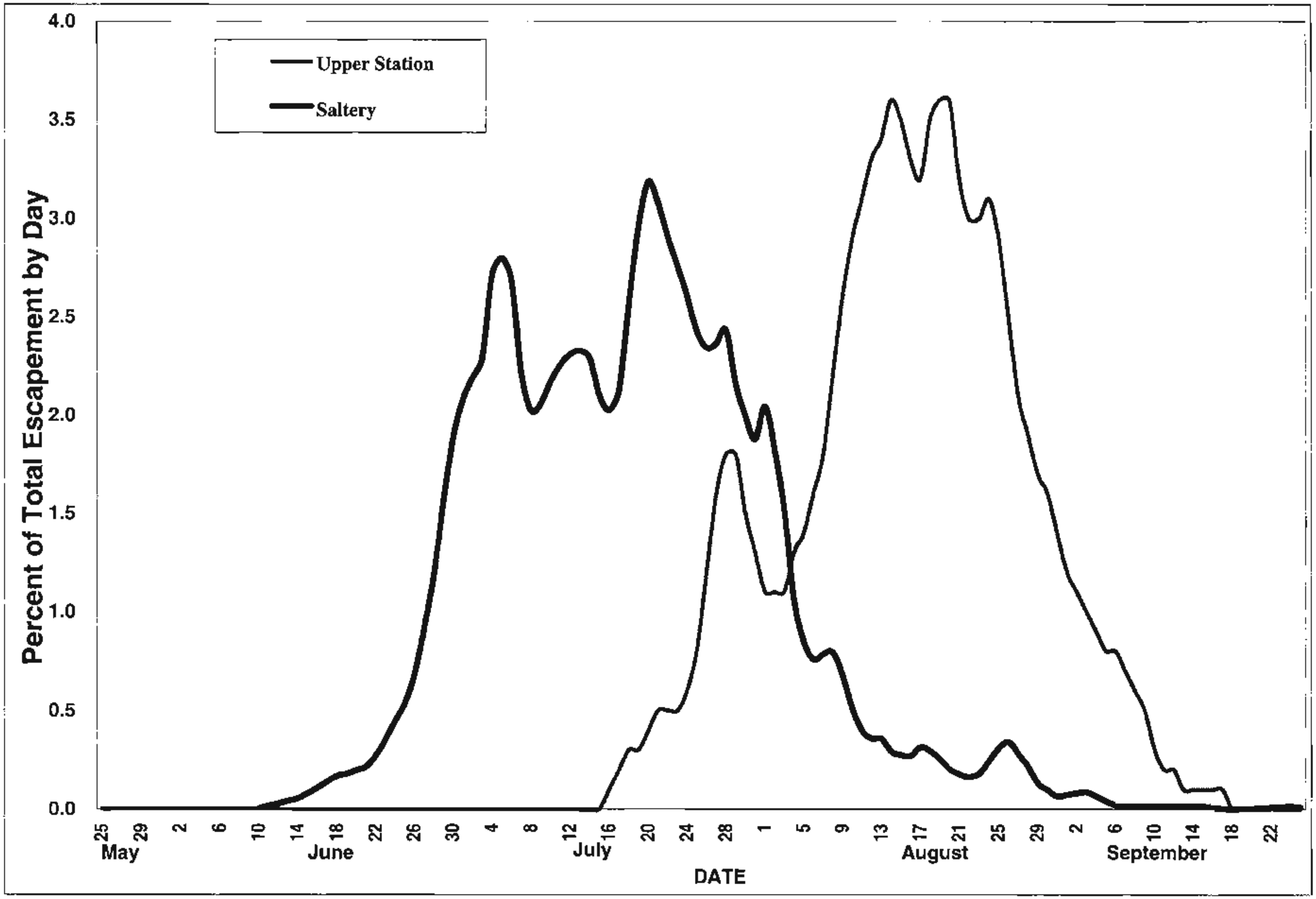


Figure 19. Projected run timing of Spiridon Lake sockeye as a function of brood source escapement timing; data smoothed from 1984-1994.

APPENDIX

Appendix A.1 Summaryof Spiridon Lake zooplankton seasonal mean density (No/m^2), biomass (mg/m^2), and size (mm), by species and sample station, 1987-1996[a].

	No. of	*Diaptomus*			*Cyclops*			*Bosmina*			*Daphnia*[b]			*Holopedium*			TOTALS	
	Sample	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass
Year	Dates	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2
STATION 1																		
1987	1	131,369	503	0.96	225,318	426	0.74	65,287	203	0.57	54,140	133	0.75	5,573	93	1.17	481,687	1358
1988	4	55,003	259	1.03	152,269	348	0.81	39,676	149	0.62	19,175	121	1.16	1,062	3	0.57	267,185	880
1989	5	106,529	316	0.88	307,829	391	0.61	41,110	125	0.56	25,849	120	1.00	3,185	22	0.82	484,502	974
1990	5	135,881	487	0.94	217,622	459	0.78	30,096	95	0.57	38,057	219	1.10	1,061	3	0.59	422,717	1263
1991	7	135,578	431	0.90	330,490	570	0.71	8,038	24	0.56	32,529	126	0.92	1,365	18	1.06	508,000	1169
1992	6	21,134	137	1.16	236,045	732	0.93	15,344	52	0.59	25,868	143	1.08	1,703	15	0.90	300,094	1079
1993	6	16,189	92	1.10	269,400	504	0.74	19,197	49	0.52	32,007	101	0.84	5,971	63	0.97	342,764	809
1994	6	8,395	41	1.04	254,211	477	0.73	22,373	63	0.55	44,959	110	0.75	12,359	81	0.79	342,297	772
1995	6	11,381	117	1.36	204,141	430	0.77	32,704	79	0.50	21,254	58	0.79	13,557	67	0.70	283,037	751
1996	6	2,796	12	1.01	336,700	694	0.77	31,228	97	0.57	20,276	82	0.96	6,281	59	0.89	397,280	944
Avg =	5	62,425	240	1.04	253,402	503	0.76	30,505	94	0.56	31,411	121	0.93	5,212	42	0.85	382,956	1000
STATION 2																		
1987																		
1988	4	51,685	227	1.01	141,653	335	0.82	37,712	110	0.59	18,912	138	1.24	465	4	0.88	250,427	814
1989	5	84,342	269	0.90	327,760	381	0.59	26,008	77	0.56	12,048	46	0.92	3,503	24	0.82	453,661	797
1990	5	86,889	434	1.05	195,754	371	0.74	12,261	43	0.60	22,080	132	1.10	1,911	12	0.78	318,895	992
1991	7	91,978	370	0.98	328,196	554	0.70	5,535	16	0.55	33,383	176	1.06	284	<1	0.46	459,376	1116
1992	5	19,522	114	1.11	286,141	803	0.89	8,306	30	0.61	23,918	100	0.95	1,858	17	0.91	339,745	1064
1993	6	5,905	26	1.01	270,081	407	0.67	13,225	32	0.51	15,857	43	0.77	1,504	7	0.68	306,572	515
1994	6	7,785	50	1.15	227,673	464	0.76	33,510	101	0.56	33,864	86	0.76	3,150	29	0.92	305,982	730
1995	6	14,251	118	1.24	222,920	528	0.82	26,973	70	0.52	36,677	97	0.77	26,115	267	0.95	326,936	1079
1996	6	2,866	9	0.90	432,511	969	0.80	25,309	84	0.59	21,417	72	0.88	11,465	93	0.84	493,568	1228
Avg =	6	40,580	180	1.04	270,299	535	0.75	20,982	63	0.57	24,240	99	0.94	5,584	57	0.80	361,685	926

[a] from G. Kyle, ADF&G, Soldotna, personal communication.

[b] *Daphnia* data are a combination of both species, *Daphnia l*. and *Daphnia r*.

Appendix A.2 Summaryof Spiridon Lake zooplankton seasonal mean density (No/m^2), biomass (mg/m^2), and size (mm), by species and sample station, 1987-1996[a].

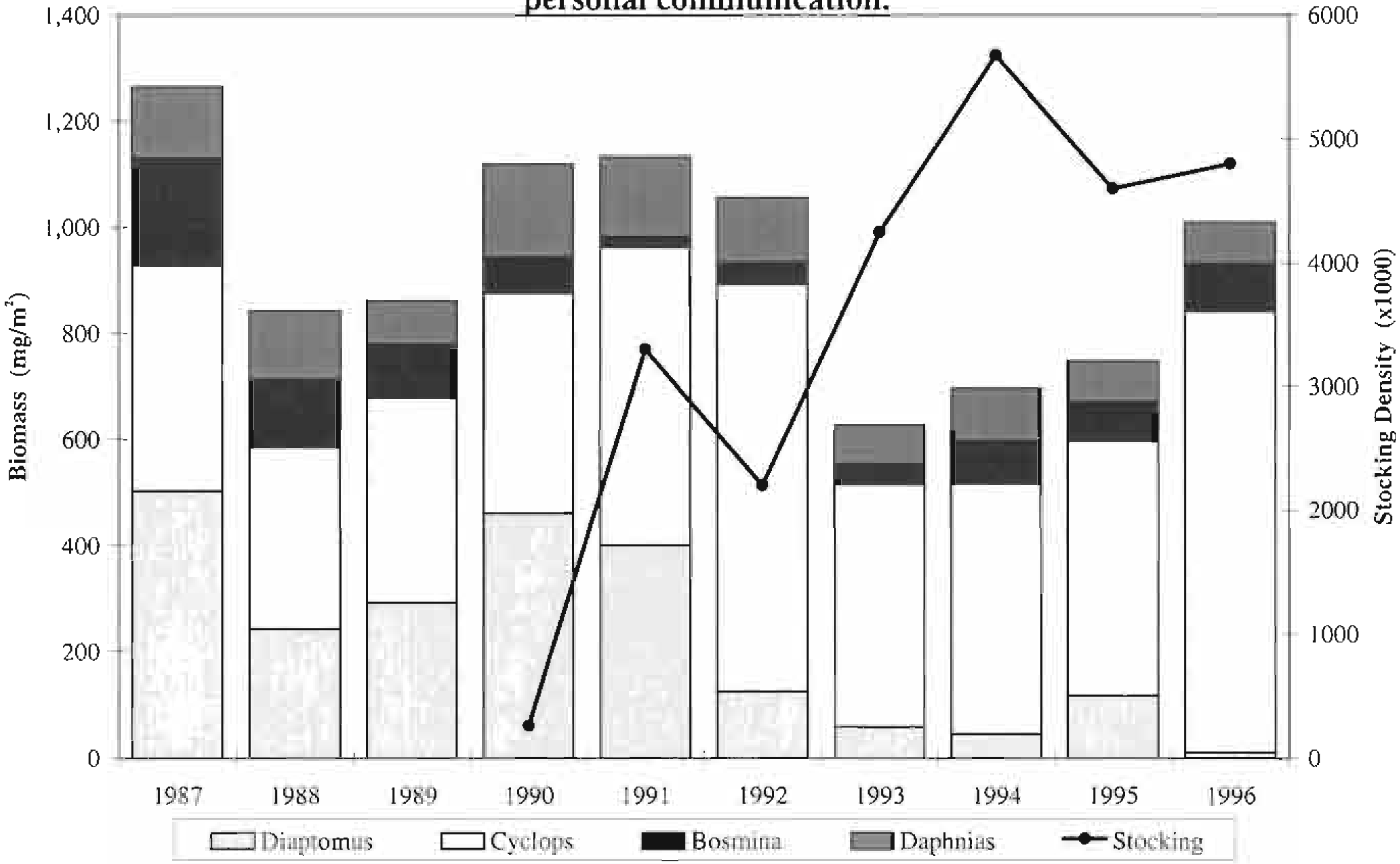
	No. of	*Diaptomus*			*Cyclops*			*Bosmina*			*Daphnia*[b]			*Holopedium*			TOTALS	
Year	Sample Dates	Density no/m^2	Biomass mg/m^2	Size mm	Density no/m^2	Biomass mg/m^2	Size mm	Density no/m^2	Biomass mg/m^2	Size mm	Density no/m^2	Biomass mg/m^2	Size mm	Density no/m^2	Biomass mg/m^2	Size mm	Density no/m^2	Biomass mg/m^2
BOTH 1 and 2																		
1987	1	131,369	503	0.96	225,318	426	0.74	65,287	203	0.57	54,140	133	0.75	5,573	93	1.17	481,687	1358
1988	4	53,344	243	1.02	146,961	342	0.82	38,694	130	0.61	19,044	130	1.20	764	4	0.73	258,806	847
1989	5	95,436	293	0.89	317,795	386	0.60	33,559	101	0.56	18,949	83	0.96	3,344	23	0.82	469,082	886
1990	5	111,385	461	1.00	206,688	415	0.76	21,179	69	0.59	30,069	176	1.10	1,486	8	0.69	370,806	1128
1991	7	113,778	401	0.94	329,343	562	0.71	6,787	20	0.56	32,956	151	0.99	825	18	0.76	483,688	1152
1992	6	20,328	126	1.14	261,093	768	0.91	11,825	41	0.60	24,893	122	1.02	1,781	16	0.91	319,920	1072
1993	6	11,047	59	1.06	269,741	456	0.71	16,211	41	0.52	23,932	72	0.81	3,738	35	0.83	324,668	662
1994	6	8,090	46	1.10	240,942	471	0.75	27,942	82	0.56	39,412	98	0.76	7,755	55	0.86	324,140	751
1995	6	12,816	117	1.30	213,531	479	0.79	29,839	74	0.51	28,966	77	0.78	19,836	167	0.83	304,987	915
1996	6	2,831	11	0.95	384,605	832	0.79	28,269	91	0.58	20,846	77	0.92	8,873	76	0.86	445,424	1086
	AVG =	56,042	226	1.03	259,602	513	0.76	27,959	85	0.56	29,320	112	0.93	5,397	49	0.84	378,321	986
STATION 3																		
1994	6	14,040	87	1.13	267,826	606	0.80	26,133	69	0.53	45,479	126	0.78	10,165	84	0.85	363,642	972
1995	5	17,187	140	1.25	228,407	549	0.82	29,172	76	0.52	36,964	132	0.89	11,900	79	0.79	323,630	976
1996	6	2,521	14	1.10	430,499	840	0.75	29,671	90	0.56	20,542	59	0.81	13,004	142	0.97	496,237	1144
Avg =	6	11,249	80	1.16	308,911	665	0.79	28,325	78	0.54	34,328	105	0.83	11,690	102	0.87	394,503	1,031
STATION 4																		
1994	5	9,766	48	1.05	299,839	503	0.6987	25,361	65	0.5188	30,765	75	0.7386	4,628	15	0.60	370,359	706
1995	6	18,144	140	1.23	167,067	363	0.78	28,256	67	0.50	23,257	54	0.72	23,301	131	0.74	260,026	755
1996	5[c]	1,327	7	1.05	266,748	610	0.81	30,246	97	0.58	22,364	92	0.98	13,163	81	0.76	333,848	887
Avg =	5	9,746	65	1.11	244,551	492	0.76	27,954	76	0.53	25,462	73	0.81	13,698	76	0.70	296,937	821

[a] from G. Kyle, ADF&G, Soldotna, personal communication.

[b] *Daphnia* data are a combination of both species, *Daphnia l*. and *Daphnia r*.

[c] Six samples were collected, one was spilled during processing.

Appendix B. Spiridon Lake seasonal mean zooplankton biomass (mg/m^2) and fry stocking density (x1000), 1987-1996; from P.Shields, ADF&G, Soldotna, personal communication.



Appendix C.1 Estimated age composition of sockeye salmon catch from Uganik Bay by week, post 14 July, 1994.[a]

Week	Sample Size		AGES 0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	3.3	4.2	Total
29	0	Percent	0.6	0.4	2.6	19.2	1.6	33.4	26.9	0.2	0	11.1	2.8	1.4	0	100
(7/12-7/18)		Numbers	53	35	230	1,713	141	2,985	2,402	18	0	989	247	124	0	8,938
30	506	Percent	0.6	0.5	2.4	20.9	1.9	30.7	26.7	0.3	0	12	2.7	1.2	0	100
(7/19-7/25)		Numbers	116	100	444	3,850	345	5,646	4,902	50	7	2,211	501	213	0	18,385
31	509	Percent	0.8	1.1	2	28.6	3	19.1	26.2	0.6	0.2	15.2	3	0.3	0	100
(7/26-8/01)		Numbers	281	360	651	9,485	987	6,328	8,665	185	58	5,030	987	96	3	33,118
32	499	Percent	1.9	0.4	4.2	38.6	1.9	5.4	31.3	0.4	0	6	9	0.7	0.2	100
(8/02-8/08)		Numbers	1,220	257	2,660	24,651	1,222	3,448	20,031	281	26	3,844	5,721	434	102	63,897
34	536	Percent	1.8	0.2	1.3	56.4	0.3	2	24.4	0.4	0.1	2.5	9.3	1.1	0.2	100
(8/16-8/22)		Numbers	412	44	307	12,946	80	459	5,598	87	34	572	2,140	241	44	22,963
35	532	Percent	0.4	0	0.8	65	0.1	0.8	23.2	0.5	0	1.8	6	1	0.3	100
(8/23-8/29)		Numbers	187	21	397	31,859	71	371	11,342	255	21	890	2,919	480	163	48,977
36	0	Percent	0	0	0.9	66.4	0.2	0.4	23.5	0.6	0	1.7	5.1	0.9	0.4	100
(8/30-9/05)		Numbers	0	0	84	5,928	17	34	2,099	50	0	151	453	84	34	8,934
38	0	Percent	0	0	0.9	66.4	0.2	0.4	23.5	0.6	0	1.7	5.1	0.9	0.4	100
(9/13-9/19)		Numbers	0	0	1	72	0	0	25	1	0	2	5	1	0	108
39	0	Percent	0	0	0.9	66.4	0.2	0.4	23.5	0.6	0	1.7	5.1	0.9	0.4	100
(9/20-9/26)		Numbers	0	0	5	374	1	2	133	3	0	10	29	5	2	564
40	0	Percent	0	0	0.9	66.4	0.2	0.4	23.5	0.6	0	1.7	5.1	0.9	0.4	100
(9/27-10/3)		Numbers	0	0	1	62	0	0	22	1	0	2	5	1	0	94
Total	2,582	Percent	1.1	0.4	2.3	44.2	1.4	9.4	26.8	0.5	0.1	6.7	6.3	0.8	0.2	100
		Numbers	2,269	817	4,780	90,940	2,864	19,273	55,219	931	146	13,701	13,007	1,679	348	205,978

[a] From Nelson and Barrett (1994).

Appendix C.2 Estimated age compostion of sockeye salmon catch from Uganik Bay, by week, post 14 July, 1995.[a]

Week	Sample Size		AGES 0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	Total
29	0	Percent	0	0	0	5	0.3	0	25.6	12.9	0	0.3	54.3	1.3	0.3	0	100
(7/12-7/18)		Numbers	0	0	0	354	22	0	1,792	907	0	22	3,805	88	22	0	7,012
30	317	Percent	1.6	1.1	1.1	9.1	1.3	0	19.6	21.8	0	0.2	41.5	2.5	0.2	0	100
(7/19-7/25)		Numbers	394	263	263	2,252	322	0	4,875	5,425	0	59	10,335	629	59	0	24,875
31	48	Percent	3	2	3.3	18.4	2.6	0	18.3	30.1	0	0	18	4.3	0	0	100
(7/26-8/01)		Numbers	1,093	729	1,193	6,659	961	0	6,628	10,932	0	0	6,529	1,557	0	0	36,280
32	81	Percent	0.1	0	2.8	17.8	0.9	0.1	28.9	17.7	0	0	27.3	3.9	0	0.4	100
(8/02-8/08)		Numbers	25	0	669	4,237	223	25	6,858	4,214	0	0	6,487	918	0	99	23,754
33	230	Percent	0.3	0.8	3.5	22.2	0.3	0.3	17.1	28.2	0	0	17.9	8	0	1.4	100
(8/09-8/15)		Numbers	70	157	710	4,532	57	70	3,496	5,761	0	0	3,648	1,627	0	279	20,407
34	203	Percent	0	9.5	0.6	21.9	1.7	0	6.1	31.7	0.1	0	7.6	20.2	0	0.5	100
(8/16-8/22)		Numbers	6	3,266	218	7,489	572	6	2,092	10,840	39	0	2,604	6,905	0	179	34,217
35	390	Percent	0	6.2	0.5	22.7	1.8	0	3.9	33.5	0.2	0	5.4	24.6	0	1	100
(8/23-8/29)		Numbers	0	2,938	248	10,695	862	0	1,836	15,764	102	0	2,536	11,581	0	481	47,042
36	498	Percent	0	1.8	0.6	21.8	0.9	0	3.9	37.8	0	0	5.3	27	0	0.9	100
(8/30-9/05)		Numbers	0	177	54	2,124	85	0	379	3,680	4	0	521	2,634	0	88	9,747
37	336	Percent	0	0	0.3	6.5	1.2	0	1.5	58	0	0	4.8	27.7	0	0	100
(9/06-9/12)		Numbers	0	0	2	40	7	0	9	355	0	0	29	169	0	0	611
38	0	Percent	0	0	0.3	6.5	1.2	0	1.5	58	0	0	4.8	27.7	0	0	100
(9/13-9/19)		Numbers	0	0	1	23	4	0	5	205	0	0	17	98	0	0	354
Total	2,103	Percent	0.8	3.7	1.6	18.8	1.5	0	13.7	28.4	0.1	0	17.9	12.8	0	0.6	100
		Numbers	1,588	7,530	3,358	38,405	3,115	101	27,970	58,083	145	81	36,511	26,206	81	1,126	204,299

[a] From Nelson and Swanton (1996).

Table C.3. Estimated age composition of sockeye salmon catch from Uganik Bay, by week, post 14 July 1996.[a]

Week	Sample Size		AGES 0.1	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	4.2	4.3	Total
29	606	Percent	0	0	0.2	1	12.2	0.2	61.6	10.3	0	13.9	0.7	0	0	0	0	100
(7/12-7/18)		Numbers	0	2	94	564	7,051	94	35,512	5,968	2	7,997	388	0	11	0	0	57,683
30	470	Percent	0	0.2	0	0.2	24.5	0	40.3	18.4	0.2	13.4	1.5	0	1.1	0	0	100
(7/19-7/25)		Numbers	0	50	5	61	6,167	11	10,155	4,645	61	3,371	383	5	280	0	0	25,194
31	773	Percent	0	0.2	0.2	0.4	29.8	0.3	35.7	21.4	0.4	9.6	1.6	0.1	0.3	0	0	100
(7/26-8/01)		Numbers	9	178	125	296	24,425	269	29,234	17,515	296	7,857	1,345	106	229	0	0	81,883
32	468	Percent	0.2	1.6	0.6	0	65.7	1.7	2.7	24.9	0	1	1.4	0.2	0	0	0	100
(8/02-8/08)		Numbers	151	1,221	477	7	51,303	1,298	2,083	19,460	18	781	1,117	164	26	0	0	78,106
33	521	Percent	0	0.2	0.3	0	54.1	1.6	0.3	33.8	0.2	2.4	6.4	0.2	0.4	0	0	100
(8/09-8/15)		Numbers	0	49	86	6	13,382	395	62	8,361	43	604	1,582	43	105	6	6	24,732
34	0	Percent	0	0.2	0.1	0.2	46.6	2	0.6	37.7	0.1	2.1	9.3	0.1	0.7	0.2	0.2	100
(8/16-8/22)		Numbers	0	55	26	42	10,333	442	139	8,348	13	467	2,051	13	153	42	42	22,168
35	363	Percent	0	0.3	0	0.3	42.9	2.2	0.8	39.6	0	1.9	10.7	0	0.8	0.3	0.3	100
(8/23-8/29)		Numbers	0	65	1	65	10,225	524	195	9,441	1	462	2,547	1	196	65	65	23,852
36	0	Percent	0	0.3	0	0.3	42.7	2.2	0.8	39.7	0	1.9	10.7	0	0.8	0.3	0.3	100
(8/30-9/05)		Numbers	0	35	0	35	5,354	276	104	4,974	0	242	1,347	0	104	35	35	12,539
37	0	Percent	0	0.3	0	0.3	42.7	2.2	0.8	39.7	0	1.9	10.7	0	0.8	0.3	0.3	100
(9/06-9/12)		Numbers	0	6	0	6	883	46	17	820	0	40	222	0	17	6	6	2,067
Total	3,201	Percent	0	0.5	0.2	0.3	39.3	1	23.6	24.2	0.1	6.6	3.3	0.1	0.3	0	0	100
		Numbers	160	1,661	814	1,082 1	29,123	3,355	77,501	79,532	434	21,821	10,982	332	1,121	154	154	328,224

[a] From Nelson and Swanton (1997).

Appendix D.1 Estimated age composition of sockeye salmon from Uyak Bay, by week, post 14 July, 1994.[a]

Week	Sample Size		AGES 0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	4.2	3.4	Total
29	0	Percent	0	0	1.4	15.1	0	39.3	19.4	0	0.4	14.5	5.5	0.4	3.9	0	0	100
(7/12-7/18)		Numbers	0	0	28	304	0	789	391	0	8	292	110	8	79	0	0	2,008
30	509	Percent	0.1	0	1.4	17.3	0	36	20.7	0	0.3	13.9	6.2	0.4	3.6	0	0	100
(7/19-7/25)		Numbers	14	0	287	3,635	0	7,569	4,358	0	68	2,929	1,307	75	756	7	0	21,006
31	525	Percent	0.4	0	1.5	27.5	0	18.9	28.4	0	0	10.5	10.5	0.2	2	0.2	0	100
(7/26-8/01)		Numbers	54	0	193	3,626	0	2,485	3,745	0	4	1,379	1,377	21	263	21	0	13,168
32	524	Percent	0.5	0	2.1	29.8	0	7.8	36.7	0	0.2	6.6	14.8	0	1.6	0	0	100
(8/02-8/08)		Numbers	198	0	773	11,141	0	2,928	13,718	0	64	2,461	5,546	3	591	3	0	37,425
34	497	Percent	0	0	1.8	47.7	0.1	2.3	31.6	0	0	2.1	12.6	0	1.8	0	0	100
(8/16-8/22)		Numbers	17	0	1,091	28,162	34	1,363	18,645	17	0	1,244	7,434	0	1,040	0	17	59,061
35	487	Percent	0.2	0	0.8	74.7	0.4	1.6	16.3	0.2	0	1.5	3.9	0	0.3	0	0.2	100
(8/23-8/29)		Numbers	146	14	649	57,382	277	1,226	12,493	159	0	1,124	2,958	0	268	0	132	76,828
36	527	Percent	0.2	0.2	0.2	51	0.2	0.6	33.8	0.4	0	1.1	12	0	0.4	0	0	100
(8/30-9/05)		Numbers	28	28	28	7,509	28	84	4,968	56	0	167	1,759	0	56	0	0	14,710
37	0	Percent	0.2	0.2	0.2	51	0.2	0.6	33.8	0.4	0	1.1	12	0	0.4	0	0	100
(9/06-9/12)		Numbers	2	2	2	473	2	5	313	4	0	11	111	0	4	0	0	927
38	0	Percent	0.2	0.2	0.2	51	0.2	0.6	33.8	0.4	0	1.1	12	0	0.4	0	0	100
(9/13-9/19)		Numbers	5	5	5	1,281	5	14	848	10	0	29	300	0	10	0	0	2,510
39	0	Percent	0.2	0.2	0.2	51	0.2	0.6	33.8	0.4	0	1.1	12	0	0.4	0	0	100
(9/20-9/26)		Numbers	13	13	13	3,401	13	38	2,250	25	0	76	796	0	25	0	0	6,662
Total	3,069	Percent	0.2	0	1.3	49.9	0.2	7	26.3	0.1	0.1	4.1	9.3	0	1.3	0	0.1	100
		Numbers	477	62	3,069	116,914	359	16,501	61,729	271	144	9,712	21,698	107	3,092	31	149	234,305

[a] From Nelson and Barrett (1994).

Appendix D.2 Estimated age compostion of sockeye salmon catch from Uyak Bay, by week, post 14 July, 1995.[a]

Week	Sample Size		AGES													
			0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	3.3	4.2	Total
29	0	Percent	0	0.2	0.8	10.8	0.4	25.6	23.7	0.2	0	34	3.4	0.8	0	100
(7/12-7/18)		Numbers	0	12	47	600	24	1,424	1,318	12	0	1,894	188	47	0	5,565
30	473	Percent	0	1.3	1	13.1	0.4	23.9	22.8	0.2	0.2	32.9	3.2	0.9	0	100
(7/19-7/25)		Numbers	26	768	592	7,562	206	13,763	13,116	103	102	18,913	1,855	515	0	57,521
31	0	Percent	0.2	5.5	1.7	22	0.1	17.8	19.5	0.1	0.8	28.6	2.6	1.1	0	100
(7/26-8/01)		Numbers	69	1,805	559	7,178	39	5,800	6,379	20	275	9,329	862	353	0	32,666
32	341	Percent	1.2	7.3	2.7	25	0.5	12.5	20.8	0	0.8	21.8	5.7	1.6	0.1	100
(8/02-8/08)		Numbers	362	2,208	821	7,588	141	3,809	6,335	0	251	6,627	1,746	486	23	30,397
33	468	Percent	1.9	4.5	2.9	17	1	6.8	30.3	0	0.1	14.2	18.5	2.4	0.2	100
(8/09-8/15)		Numbers	503	1,201	774	4,531	268	1,803	8,078	0	39	3,793	4,936	643	53	26,622
34	548	Percent	0.6	1.2	1.3	8	0.6	3.5	38.1	0	0	13.4	30.6	2.3	0.2	100
(8/16-8/22)		Numbers	279	561	607	3,668	291	1,604	17,372	0	5	6,128	13,962	1,066	71	45,613
35	999	Percent	1	1.8	0.8	6.8	0.8	3.7	40.7	0.1	0	5.8	37.3	1.2	0	100
(8/23-8/29)		Numbers	400	700	294	2,617	312	1,415	15,717	29	0	2,225	14,397	475	1	38,581
36	0	Percent	0.4	0.8	0.5	4.6	0.5	2.4	37.3	0.4	0	6.3	45.7	1.2	0	100
(8/30-9/05)		Numbers	176	307	223	1,865	185	957	15,172	159	0	2,544	18,570	494	0	40,652
37	490	Percent	0	0	0.4	3.1	0.2	1.5	35	0.6	0	6.7	51.2	1.2	0	100
(9/06-9/12)		Numbers	2	4	57	427	29	201	4,783	82	0	918	6,996	167	0	13,667
38	0	Percent	0	0	0.4	3.1	0.2	1.4	34.9	0.6	0	6.7	51.4	1.2	0	100
(9/13-9/19)		Numbers	0	0	22	167	11	78	1,909	33	0	368	2,813	67	0	5,469
39	0	Percent	0	0	0.4	3.1	0.2	1.4	34.9	0.6	0	6.7	51.4	1.2	0	100
(9/20-9/26)		Numbers	0	0	2	15	1	7	171	3	0	33	252	6	0	490
Total	3319	Percent	0.6	2.5	1.3	12.2	0.5	10.4	30.4	0.1	0.2	17.8	22.4	1.5	0	100
		Numbers	1,817	7,566	3,998	36,218	1,507	30,861	90,350	441	672	52,772	66,577	4,319	148	297,243

[a] From Nelson and Swanton (1996).

Appendix D.3 Estimated age composition of sockeye salmon catch from Uyak Bay by week, post 14 July, 1996.[a]

Week	Sample Size		AGES 0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	2.3	3.2	2.4	3.3	4.2	4.3	Total
29	480	Percent	0.5	0	1.6	13.8	0.2	30.7	24.3	0	19.3	3.3	0.2	6	0	0	100
(7/12-7/18)		Numbers	59	5	206	1,756	31	3,914	3,091	5	2,462	417	24	763	3	0	12,736
30	439	Percent	0.9	0.4	1.2	21.7	2.5	16.6	34.6	0.4	11.4	4.6	0	5.5	0.2	0	100
(7/19-7/25)		Numbers	50	24	69	1,266	145	970	2,021	24	664	271	1	322	12	0	5,841
31	468	Percent	0.1	0	1	21.3	0.1	14	34.1	0	14.5	9.5	0	5	0.2	0.4	100
(7/26-8/01)		Numbers	19	0	367	8,083	30	5,317	12,955	0	5,493	3,623	0	1,885	71	143	37,986
32	491	Percent	0.4	0	0.2	31.6	0.6	2.6	54.2	0	3.4	6.1	0	0.8	0	0	100
(8/02-8/08)		Numbers	87	0	47	6,724	119	558	11,528	0	722	1,302	0	163	2	3	21,256
33	510	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/09-8/15)		Numbers	182	0	0	9,546	0	227	11,091	0	273	1,773	0	91	0	0	23,183
34	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/16-8/22)		Numbers	213	0	0	11,174	0	266	12,984	0	319	2,075	0	106	0	0	27,138
35	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/23-8/29)		Numbers	200	0	0	10,487	0	250	12,185	0	300	1,948	0	100	0	0	25,469
36	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(8/30-9/05)		Numbers	163	0	0	8,566	0	204	9,952	0	245	1,591	0	82	0	0	20,802
37	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(9/06-9/12)		Numbers	111	0	0	5,808	0	138	6,748	0	166	1,079	0	55	0	0	14,104
38	0	Percent	0.8	0	0	41.2	0	1	47.8	0	1.2	7.6	0	0.4	0	0	100
(9/13-9/19)		Numbers	11	0	0	574	0	14	667	0	16	107	0	5	0	0	1,394
Total	2,388	Percent	0.6	0	0.4	33.7	0.2	6.2	43.8	0	5.6	7.5	0	1.9	0	0.1	100
		Numbers	1,095	29	689	63,984	325	11,858	83,222	29	10,660	14,186	25	3,572	88	146	189,909

[a] From Nelson and Swanton (1997).

Appendix E.1 Estimated age compostions of sockeye salmon catch from Spiridon Bay Terminal Harvest Area (SBTHA) by week, 1994.[a]

Week	Sample Size		AGES 1.1	1.2	2.1	1.3	2.2	2.3	Total
32	269	Percent	0	99.3	0	0.3	0	0.3	100
(8/02-8/08)		Numbers	0	310	0	1	0	1	312
33	262	Percent	0.1	99.8	0.1	0	0	0	100
(8/09-8/15)		Numbers	56	77,661	56	8	0	8	77,789
34	326	Percent	0.5	98.9	0.5	0	0	0	100
(8/16-8/22)		Numbers	73	13,738	75	2	2	0	13,890
35	290	Percent	0.2	98.9	0.6	0.2	0.2	0	100
(8/23-8/29)		Numbers	20	9,884	56	19	19	0	9,997
36	78	Percent	0	98.7	1.3	0	0	0	100
(8/30-9/05)		Numbers	0	13,031	169	0	0	0	13,200
Total	1,329	Percent	0.1	99.5	0.3	0	0	0	100
		Numbers	149	114,624	356	30	21	9	115,188

[a] From Nelson and Barrett (1994).

Appendix E.2 Estimated age composition of sockeye salmon catch from Spiridon Bay Terminal Harvest Area (SBTHA) by week, 1995.[a]

Week	Sample Size		AGES								Total
			0.2	1.1	0.3	1.2	2.1	1.3	2.2	2.3	
30	60	Percent	0	27.9	1.6	34.5	1.6	6.7	16.4	11.4	100
(7/19-7/25)		Numbers	0	490	28	605	28	117	289	200	1,757
31	249	Percent	0	21.1	0.3	52.6	0.9	6	12.9	6.1	100
(7/26-8/01)		Numbers	0	672	9	1,673	29	189	411	195	3,178
32	174	Percent	0	20.2	0	63	0.8	3.4	12	0.5	100
(8/02-8/08)		Numbers	0	539	0	1,678	21	91	320	14	2,663
33	237	Percent	0	21.8	0	62.3	1.8	4.4	9.7	0	100
(8/09-8/15)		Numbers	0	2,306	0	6,602	195	465	1,031	0	10,600
34	184	Percent	0	12.5	0	68.1	1.4	4.2	13.8	0	100
(8/16-8/22)		Numbers	0	866	0	4,710	98	289	951	0	6,914
35	239	Percent	0.1	22.5	0	56.8	3.3	6.4	10.8	0	100
(8/23-8/29)		Numbers	5	894	0	2,254	133	256	428	0	3,970
36	170	Percent	0.5	20.9	0	60	3.5	6	9.1	0	100
(8/30-9/05)		Numbers	13	514	0	1,477	86	147	224	0	2,461
37	0	Percent	0.6	20.6	0	60.6	3.5	5.9	8.8	0	100
(9/06-9/12)		Numbers	1	31	0	90	5	9	13	0	149
Total	1313	Percent	0.1	19.9	0.1	60.2	1.9	4.9	11.6	1.3	100
		Numbers	19	6,312	37	19,089	595	1,563	3,667	409	31,692

[a] From Nelson and Swanton (1996).

Appendix E.3. Estimated age composition of sockeye salmon catch from Spiridon Bay Terminal Harvest Area (SBTHA) by week, 1996.[a]

Week	Sample Size		AGES 1.1	1.2	2.1	1.3	2.2	3.1	3.2	Total
31	328	Percent	0.6	87.2	0.5	0	11.5	0	0.3	100
(7/26-8/01)		Numbers	163	23,589	123	8	3,106	0	78	27,066
32	207	Percent	0.7	85.9	2.7	0.4	10.2	0	0	100
(8/02-8/08)		Numbers	232	29,483	936	141	3,506	0	11	34,309
33	360	Percent	1.9	81	3.8	0.3	12.9	0	0	100
(8/09-8/15)		Numbers	818	34,513	1,639	128	5,488	0	0	42,586
34	204	Percent	2.1	70.8	6.5	0	20.5	0	0	100
(8/16-8/22)		Numbers	945	32,033	2,953	23	9,280	9	0	45,242
35	423	Percent	4.2	68.4	12	0	14.9	0.5	0	100
(8/23-8/29)		Numbers	417	6,791	1,187	0	1,475	53	0	9,923
36	241	Percent	9	57.7	20.4	0	11	1.8	0	100
(8/30-9/05)		Numbers	240	1,529	541	0	290	48	0	2,648
37	112	Percent	9.1	53.9	20	0.7	13.6	0.3	2.2	100
(9/06-9/12)		Numbers	31	185	69	3	47	1	8	344
Total	1,875	Percent	1.8	79	4.6	0.2	14.3	0.1	0.1	100
		Numbers	2,846	128,123	7,448	303	23,192	111	97	162,118

[a] From Nelson and Swanton (1997).

Appendix F. Estimated number of Spiridon Lake sockeye salmon harvested by district, area, and week 05 July - 05 September, 1994.[a]

District Area	Week	Dates	Age Sample (Numbers) Total	Age Sample (Numbers) Est. Spiridon Component	Catch Number of Fish	Catch Est. Spiridon Percent	Catch Est. Spiridon Number
NW Kodiak							
Uganik Bay	28	7/05-7/11	391	0	25,927	0	0
	29	7/12-7/18	0		30,360		
	30	7/19-7/25	506	15	18,385	3.0	545
	31	7/26-8/01	509	47	33,118	9.2	3,058
	32	8/02-8/08	499	173	63,897	34.7	22,153
	33	8/09-8/15	0		No fishery		
	34	8/16-8/22	536	265	22,963	49.4	11,353
	35	8/23-8/29	532	289	48,977	54.3	26,606
	36	8/30-9/05	0 [b]		8,887		4,611
Total			2,973	789	252,514	27.1	68,325
Uyak Bay	28	7/05-7/11	522	0	18,454	0	0
	29	7/12-7/18	509	0	12,907	0	0
	30	7/19-7/25	509	41	21,006	8.1	1,692
	31	7/26-8/01	525	106	13,942	20.2	2,815
	32	8/02-8/08	524	117	37,425	22.3	8,356
	33	8/09-8/15	0		No fishery		
	34	8/16-8/22	497	165	59,061	33.2	19,608
	35	8/23-8/29	487	283	76,828	58.1	44,645
	36	8/30-9/05	527 [c]	210	14,698	39.8	627
Total			4,100	922	254,321	30.6	77,744
Telrod Cove	28	7/05-7/11	0		No fishery		
	29	7/12-7/18	0		No fishery		
	30	7/19-7/25	0		No fishery		
	31	7/26-8/01	0		No fishery		
	32	8/02-8/08	269		312	99.3	310
	33	8/09-8/15	262		78,424	99.9	78,346
	34	8/16-8/22	326		13,890	99.4	13,807
	35	8/23-8/29	290		9,997	99.5	9,947
	36	8/30-9/05	78		13,200	100	13,200
Total			1,225		115,823	99.8	115,609
NW Kodiak Total			8,298	1,711	622,658	42.0	261,678
SW Kodiak							
Inner/Outer Karluk	28	7/05-7/11	506	0	39,529	0.0	0
	29	7/12-7/18	0		3,887		
	30	7/19-7/25	0		11,066		
	31	7/26-8/01	349	25	8,041	7.2	576

-Continued-

District Area	Week	Dates	Age Sample (Numbers) Total	Age Sample (Numbers) Est. Spiridon Component	Catch Number of Fish	Catch Est. Spiridon Percent	Catch Est. Spiridon Number
	32	8/02-8/08	0		2,885		
	33	8/09-8/15	0		No fishery		
	34	8/16-8/22	0		No fishery		
	35	8/23-8/29	0		No fishery		
	36	8/30-9/05	0		No fishery		
Total			855	25	65,408	<1%	576
Sturgeon	28	7/05-7/11	0		No fishery		
	29	7/12-7/18	0		No fishery		
	30	7/19-7/25	0		No fishery		
	31	7/26-8/01	0		3,887		
	32	8/02-8/08	0		No fishery		
	33	8/09-8/15	0		No fishery		
	34	8/16-8/22	0		No fishery		
	35	8/23-8/29	0		No fishery		
	36	8/30-9/05	0		No fishery		
Total					3,887	0%	0
Halibut Bay	28	7/05-7/11	0		No fishery		
	29	7/12-7/18	0		No fishery		
	30	7/19-7/25	507	0	14,692	0.0	0
	31	7/26-8/01	497	3	18,441	0.6	111
	32	8/02-8/08	385	62	8,598	16.1	1,385
	35	8/23-8/29	0		4,700		
	36	8/30-9/05	0		5,210		
Total			1,389	65	51,641	2.9%	1,496
Inner/Outer Ayakulik	28	7/05-7/11	0		No fishery		
	29	7/12-7/18	0		No fishery		
	30	7/19-7/25	443	0	19,554	0.0	0
	31	7/26-8/01	527	0	10,983	0.0	0
	32	8/02-8/08	0		9,821		
	35	8/23-8/29	0		4,250		
	36	8/30-9/05	0		3,925		
Total			970	0	48,533	0%	0
SW Kodiak Total			3,214	90	169,469	1.2%	2,072
Grand Total			11,512	1,801	792,127	33.3%	263,750

[a] from Nelson and Barrett (1994).

[b] No sample was collected due to mixed tender deliveries.

[c] Sample was a mixture of Uyak Bay and Spiridon Special Havest Area catch. Catch assignment method #2 was used.

Appendix G.1. Estimated numbers of age 1.2 sockeye salmon of Spiridon lake origin harvested in the Uganik and Uyak catch areas, by week, 1995.[a]

				Stock Composition Estimates (percent)						Catch	
				Spiridon		Ayakulik		Upper Station			
Catch Area	Week	Catch Dates	Sample Size	estimate	SE	estimate	SE	estimate	SE	total age 1.2	assigned to Spiridon
Uganik	30	7/19-7/25	16	31.3	[b]					2,252	705
	31	7/26-8/01	31	82.6	16.4	17.4	25.2	0.0	9.8	6,659	5,500
	32	8/02-8/08	31	82.6	16.4	17.4	25.2	0.0	9.8	4,237	3,500
	33	8/09-8/15	31	82.6	16.4	17.4	25.2	0.0	9.8	4,532	3,743
	34	8/16-8/22	46	82.4	13.5	14.8	18.4	2.7	14.5	7,489	6,171
	35	8/23-8/29	46	82.4	13.5	14.8	18.4	2.7	14.5	10,695	8,813
	36	8/30-9/05	71	71.9	12.5	17.8	17.3	10.3	15.6	2,124	1,527
	Area Total									37,988	29,959
Uyak	30	7/19-7/25	51	33.3						7,562	2,518
	31	7/26-8/01	50	84.1	12.5	9.0	16.1	6.7	14.6	7,178	6,037
	32	8/02-8/08	50	84.1	12.5	9.0	16.1	6.7	14.6	7,588	6,382
	33	8/09-8/15	52	85.0	14.7	10.0	21.9	5.0	15.9	4,531	3,851
	34	8/16-8/22	30	85.6	20.7	10.0	21.9	4.4	12.6	3,668	3,140
	35	8/23-8/29	46	74.2	16.2	10.0	21.9	15.8	23.5	2,617	1,942
	36	8/30-9/05	46	74.2	16.2	10.0	21.9	15.8	23.5	1,865	1,384
	Area Total									35,009	25,253
Combined Total										72,997	55,212

[a] From Nelson and Swanton (1996).

[b] Visual id method no SE

Appendix G.2. Estimated number of Spiridon Lake sockeye salmon harvested by area and week, 1995.[a]

		Catch Area							
	Catch	Uganik			Uyak				Total Estimated
Week	Dates	1.1	1.2	Total	1.1	1.2	Total	all ages combined	Spiridon Harvest
29	7/15-7/18	0	0	0	0	0	0	0	0
30	7/19-7/25	0	705	705	768	2,518	3,286	1,757	5,748
31	7/26-8/01	729	5,500	6,229	0	6,037	6,037	3,178	15,444
32	8/02-8/08	0	3,500	3,500	1,954	6,382	8,336	2,663	14,498
33	8/09-8/15	0	3,743	3,743	968	3,851	4,819	10,600	19,163
34	8/16-8/22	2,352	6,171	8,523	561	3,140	3,701	6,914	19,138
35	8/23-8/29	2,098	8,813	10,911	300	1,942	2,242	3,970	17,122
36	8/30-9/05	71	1,527	1,598	0	1,384	1,384	2,461	5,443
37	9/06-9/12	0	0	0	0	0	0	149	149
Area Totals									
	Number	5,250	29,959	35,209	4,551	25,253	29,804	31,692	96,705
	Percent			36.4%			30.8%	32.8%	100.0%

[a] From Nelson and Swanton (1996).

Appendix G.3. Estimated number of Spiridon Lake sockeye salmon harvested by area and week, 1996.

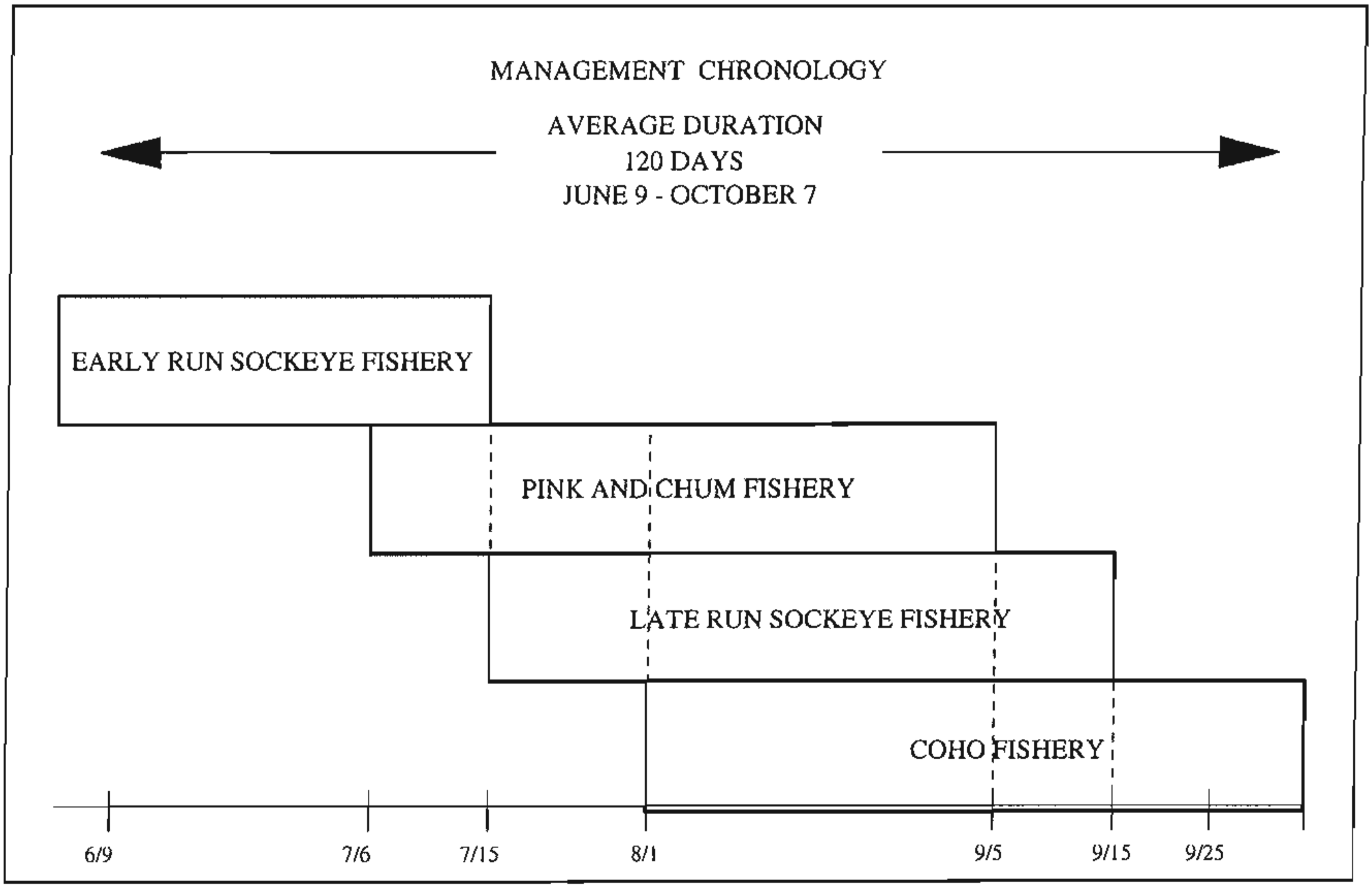
		Catch Area												
		SW Afognak (251-10-20)			Uganik (253-11-35)			Uyak (254-10-40)			Telrod Cove (254-50)			
Catch week	Dates	1.2	other	total	1.2	other	total	1.2	other	total	1.2	other	total	Total
29	7/12-7/18	0	0	0	4652	683	5335	1298	191	1488				6824
30	7/19-7/25	0	0	0	6167	906	7073	1258	185	1443				8516
31	7/26-8/01	4051	595	4646	22276	3271	25547	7622	1119	8742	23589	3477	27066	66000
32	8/02-8/08	1247	195	1442	51303	8025	59328	6724	1052	7776	29483	4826	34309	102855
33	8/09-8/15	984	238	1222	13382	3230	16612	9546	2304	11850	34513	8073	42586	72270
34	8/16-8/22	1075	491	1566	10333	4724	15057	11174	5108	16282	32033	13209	45242	78147
35	8/23-8/29	0	0	0	10225	4486	14711	10487	4601	15088	6791	3132	9923	39723
36	8/30-9/05	0	0	0	5354	4275	9629	0	0	0	1529	1119	2648	12277
37	9/06-9/12	0	0	0	0	0	0	0	0	0	185	159	344	344
Area Total		7357	1519	8876	123692	29601	153292	48109	14560	62670	128123	33995	162118	386956

[a] From Nelson and Swanton (1997).

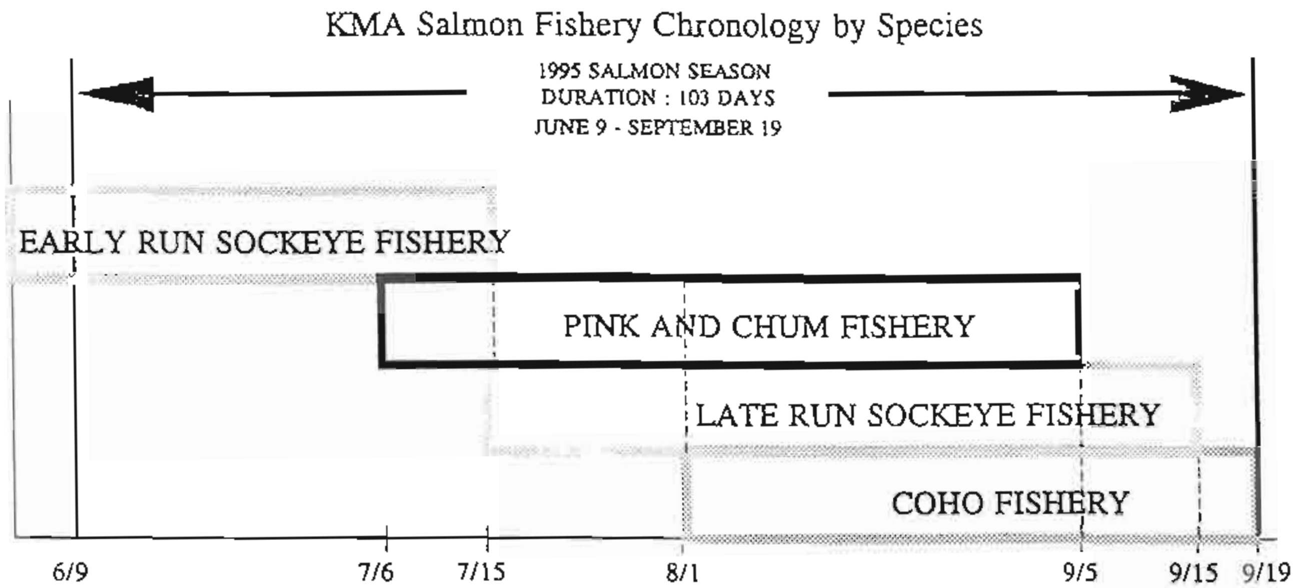
Appendix H. Average number of salmon (all species) and sockeye salmon landings by purse seine and gillnet by week for Uganik Bay, and Uyak Bay, 1970-1993 and 1994-1996.[a]

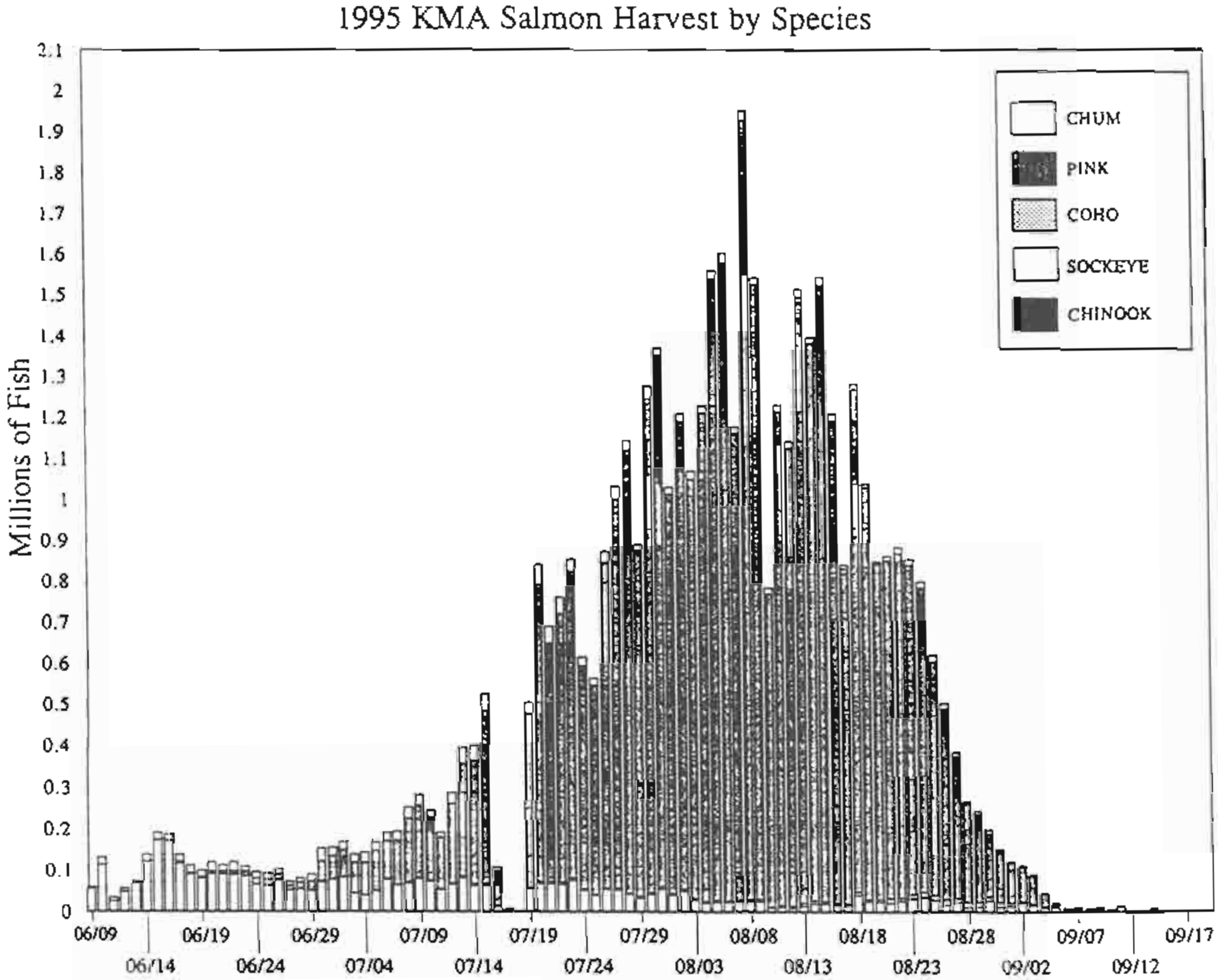
		Purse seine landings				Gillnet landings			
	Week Ending	All Species		Sockeye		All Species		Sockeye	
Area	Date	1970-1993	1994-1996	1970-1993	1994-1996	1970-1993	1994-1996	1970-1993	1994-1996
Uganik	18-Jul	107.43	93.33	97.52	90.00	170.83	144.67	168.39	144.67
	25-Jul	130.45	98.33	110.45	94.33	183.04	181.33	179.17	180.33
	1-Aug	138.35	90.33	113.55	88.67	197.70	193.00	190.74	192.00
	8-Aug	128.36	110.00	97.77	107.67	191.23	203.00	181.64	203.00
	15-Aug	137.86	104.00	103.57	73.50	197.38	182.00	188.67	181.50
	22-Aug	92.95	151.67	74.00	122.00	107.05	155.00	103.42	154.33
	29-Aug	54.80	101.00	38.68	96.67	59.62	174.33	58.15	173.67
	5-Sep	20.58	27.00	18.33	24.67	51.06	104.00	56.57	102.67
Uyak	18-Jul	100.81	59.00	49.42	48.00	123.39	111.67	119.91	110.67
	25-Jul	95.74	134.67	52.61	111.67	133.74	164.67	128.78	164.33
	1-Aug	95.55	134.00	61.05	115.00	147.09	171.33	140.68	168.00
	8-Aug	74.86	116.67	50.00	105.00	147.05	175.67	140.27	172.67
	15-Aug	89.86	141.00	75.85	103.00	148.10	172.00	143.00	169.00
	22-Aug	67.22	127.67	66.13	91.33	82.12	146.00	80.06	142.00
	29-Aug	74.25	119.67	74.27	112.67	46.00	121.00	45.83	121.00
	5-Sep	46.13	61.67	71.75	56.00	46.50	85.67	50.27	85.33

[a] Data from C. Hicks, ADF&G, Kodiak, personal communication

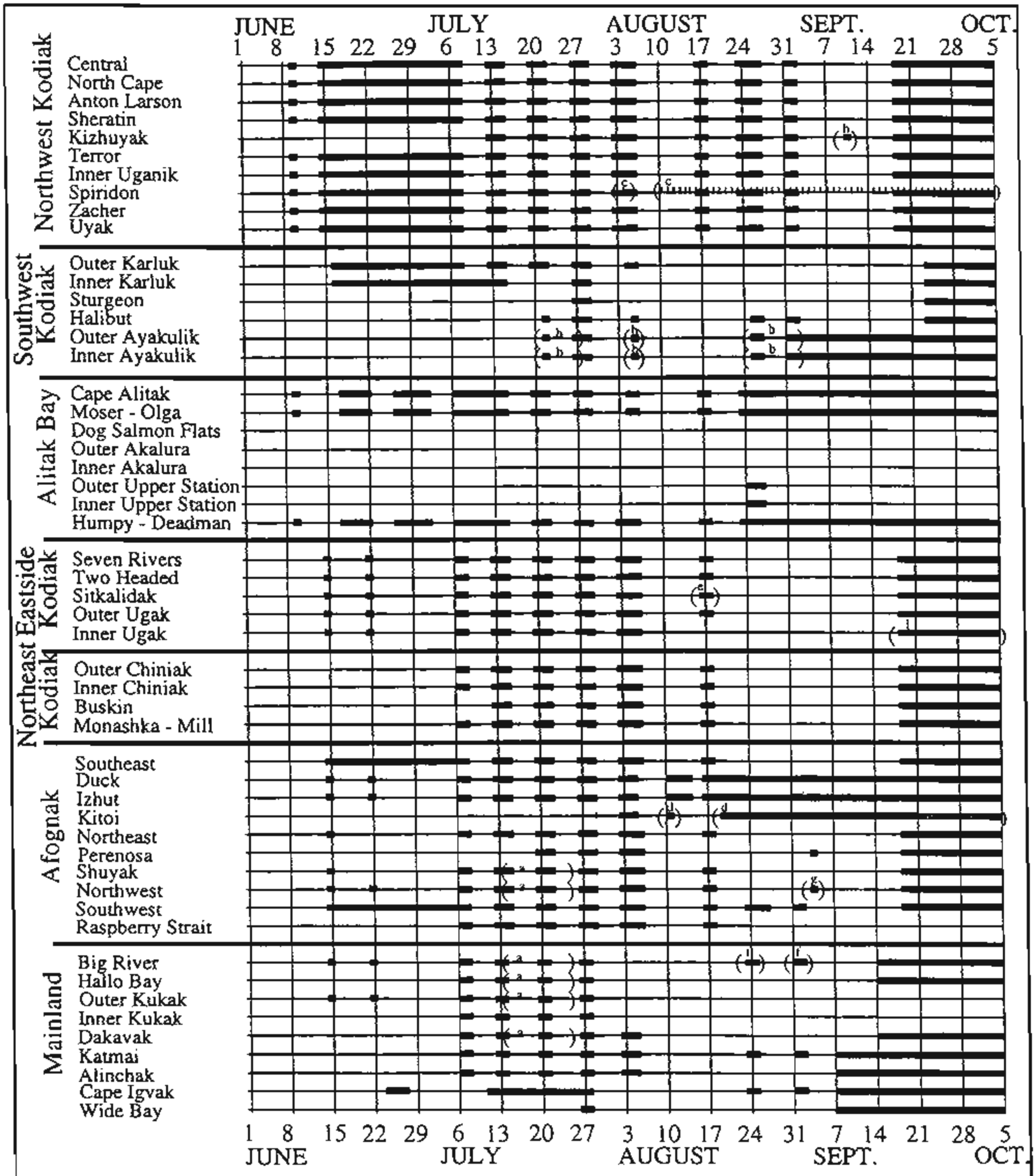


Appendix I.1. Commercial salmon fishery chronology, by species, in the Kodiak Management Area, 1994; from Brennan et al (1996).



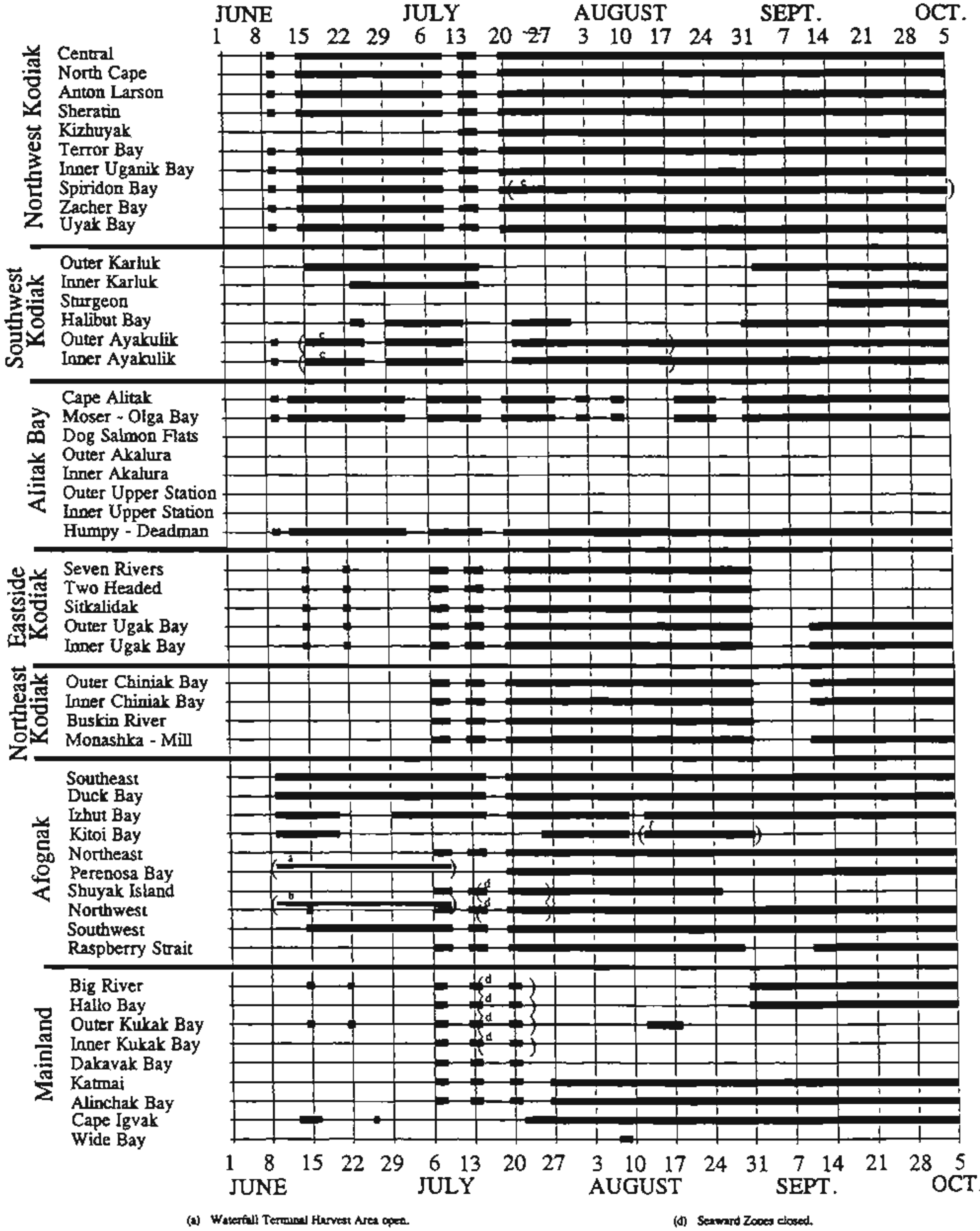


Appendix I.2. Commercial salmon fishery chronology, by species, in the Kodiak Management Area, 1995; from Brennan et al (1997).



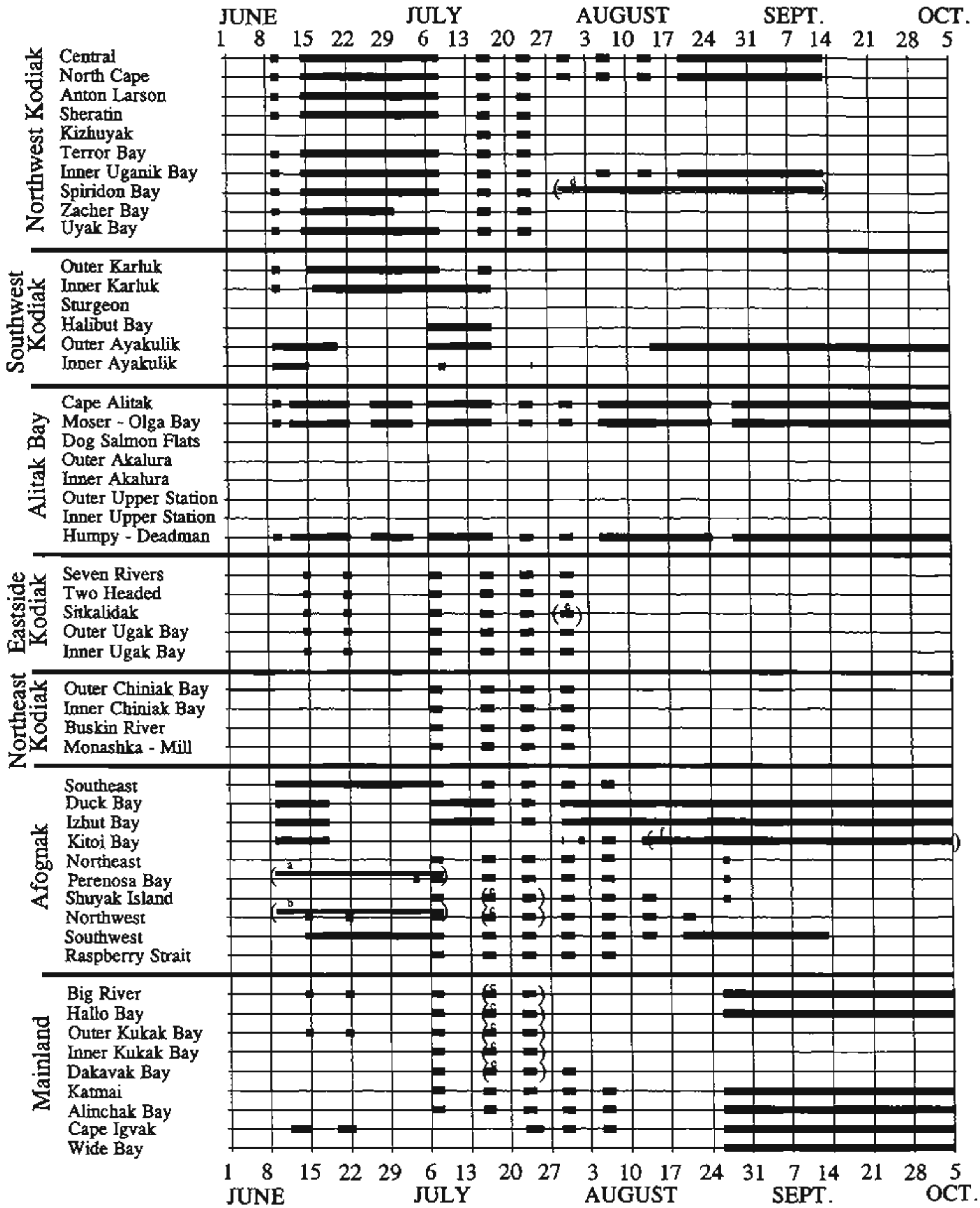
(a) Seaward Zones closed.
(b) Inner and Outer Ayakulik south of 57 13'09" N. lat. remains closed.
(c) Spiridon Bay Special Harvest Area openings.
(d) Kitoi Bay Section west of the Jaws remains closed.
(e) Sitkalidak Section in Kiliuda inside of a line from Left Cape to Pillar Point remains closed.
(f) Big River south of 58 34'30" N. lat. remains closed.
(g) Special Harvest opening in Foul Bay east of 152 47'12" W. long.
(h) Special Harvest opening in Settler Cove west of 152 50'48" W. long.
(i) Outer Ugak south of latitude of Gull Point remains closed.

Appendix I.3. Commercial salmon fishing time, by district and section, in the Kodiak Management Area, 1994; from Brennan et al (1996).



(a) Waterfall Terminal Harvest Area open.
(b) Foul Bay Terminal Harvest Area open.
(c) Inner and Outer Ayakulik south of 57°13'09" N. lat. remains closed.
(d) Seaward Zones closed.
(e) Spiridon Bay Special Harvest Area open.
(f) Kitoi Bay Section west of the Jaws remains closed.

Appendix I.4. Commercial salmon fishing time, by district and section, in the Kodiak Management Area, 1995; from Brennan et al (1997).



(a) Waterfall Terminal Harvest Area open.
(b) Foul Bay Terminal Harvest Area open.
(c) Seaward Zones closed 10PM 7/15.
(d) Only Spiridon Lake Terminal Harvest Area open.
(e) Kiliuda Bay remains closed.
(f) Kitoi Bay Section west of the Jaws remains closed.

Appendix I.5. Commercial salmon fishing time, by district and section, in the Kodiak Management Area, 1996; from Brennan et al (in press).

Appendix J.1. Index aerial escapement surveys of Spiridon and Telrod Creek, 1994.[a]

Stream	Date MM-DD-Y'	Observer	Visibility Str	Mou	Bay	Fish in Stream Sockeye	Coho	Pink	Chum	Build Up Fish Mouth	Bay	Observer Remarks
SPIRIDON RIVER												
254-401	7/27/94	PROKOPOWICH	P	P		0	0	0	20			Water muddy. Nothing seen in bay.
254-401	8/5/94	HANDER	P	P		0	0	0	0			1145 HRS. River too turbid to get any counts. Looked at side streams and they were also very turbid.
254-401	8/8/94	HANDER	F			0	0	1000	3000			1528 HRS. Good stream flow and best visibility so far this year. Side streams and clear tributaries were where we saw most all fish.
254-401	8/8/94	PROKOPOWICH	P	F		0	0	0	0	1500Ch		Water murky still. Only a few fish seen toward Weasel Cove.
254-401	8/12/94	KEVIN BRENNAN	P	P	F	0	0	0	0		8000P	Time: 1345. River and flats too turbid and murky to see fish. Two small schools in Weasel Cove.
254-401	8/19/94	HANDER	G	P		20	0	7000	3000			Time: 1318 hrs. Moderate to good stream flow. Surveyed entire system, chums seen in upper river clear side tributaries.
254-401	8/31/94	BARRETT/CHATTO	E			375	0	12800	10300			1400 HRS. Joint survey with USFWS. Surveyed entire stream by helicopter, including Munsey's Lake. All reds in Munsey's Lake and index area for chums (BB - Munsey Lake had 300 sockeye; 90% of the chums in northwest tributary). General feeling there were more pinks than what was counted. Lots of pink carcasses in Munsey tributary.

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Appendix J.1. (page 2 of 2)

Stream	Date MM-DD-Y	Observer	Visibility Str	Mou	Bay	Fish in Stream Sockeye	Coho	Pink	Chum	Build Up Fish Mouth	Bay	Observer Remarks
254-401	9/30/94	JOHNSON	G			100	2900	0	0			1200 HRS. Surveyed entire river from index area to bay. Good survey conditions. All sockeye in Munsey's Lake. Water flow fair. Lots of Dollies.
254-401	10/18/94	JOHNSON	E			0	4800	0	0			1223 HRS. Surveyed entire stream to cascades above lagoon. 100 coho in Munsey's Lake. Excellent conditions - good survey.
TELROD	***COVE***											
254-403	7/27/94	PROKOPOWICH		G		0	0	0	0			
254-403	8/5/94	HANDER	F	F		0	0	0	0			
254-403	8/5/94	HONNOLD	G	G		300	0	0	0			
254-403	8/8/94	PROKOPOWICH		G		0	0	0	0			
254-403	8/23/94	HONNOLD	G	G		3500	0	0	0			
254-403	9/6/94	HONNOLD	G			2200	0	475	0			
254-403	9/30/94	JOHNSON	F			3000	0	0	0			
254-403	10/18/94	JOHNSON	P			0	0	0	0			

[a] From Brennan et al. (1996).

Appendix J.2. Index aerial escapement surveys of Spiridon and Telrod Creek, 1995.[a]

Stream	Date MM-DD-YY	Observer	Visibility Str	Mou	Bay	Fish in Stream Sockeye	Coho	Pink	Chum	Build Up Fish Mouth	Bay	Observer Remarks
SPIRIDON RIVER												
254-401	7/26/95	PROKOPOWICH	P	P	P	0	0	0	0		9000P	Pinks by Weasel Cove. Bay and river murky, no survey of stream.
254-401	8/15/95	HANDER	G			5	0	24700	13300			1620 HRS. Incoming tide, good stream flow. Good distribution of both pink and chum spawners throughout the river. Surveyed entire river. More evidence of reds spawning in Munsey Lake.
254-401	8/17/95	KEVIN BRENNAN	G	G	F	0	0	59800	22000		18000P	1505 HRS. Quick look at bay; fish in Weasel Cove. No fish seen on flats. Good distribution of pinks and chums in middle and upper reaches of river; very few fish in lower river. Plus 10,000 carcasses.
254-401	8/22/95	JOHNSON	F			450	0	34000	11000			1209 HRS. Surveyed entire river including Munsey's Lake. 250 reds in Munsey's Lake, rest are scattered below Munsey's Creek and in index area. 4 single bears/1 sow, 2 yearlings fishing.
254-401	9/3/95	KEVIN BRENNAN	G	E	E	0	600	24000	6000			TIME: 1225 HRS. Stream survey from Little Lake down. Water kind of murky. Lots of carcasses - at least 65,000 (50% chum). No bay survey.
254-401	9/13/95	HANDER	F	P		220	1500	3500	200			1457 HRS. Mid-incoming tide. Good stream flow. Surveyed entire river. One small pocket of sockeye seen in river and the rest were in Munsey Lake. Chums were in the upper index area side stream. Shallow areas in the river had good visibility.

-Continued-

Appendix J.2. (page 2 of 2)

Stream	Date MM-DD-YY	Observer	Visibility Str	Visibility Mou	Visibility Bay	Fish in Stream Sockeye	Fish in Stream Coho	Fish in Stream Pink	Fish in Stream Chum	Build Up Fish Mouth	Build Up Fish Bay	Observer Remarks
254-401	9/28/95	HANDER	P	P		20	120	0	0			1400 HRS. Flow high but not bank to bank. Very poor survey conditions. All coho observed were above the confluence of Munsey's Lake. Some major changes observed in stream channel in the index area and most of the mainstem flow now is channeled through the index area. Munsey's Lake and creek very high and turbid, no fish observed. (Bears - 4 single) (2 swans in lake)
254-401	10/13/95	JOHNSON	G			250	10300	0	0			1455 HRS. Surveyed entire stream except for lower rapids. Low flow. Excellent look, best survey conditions this year. All sockeye at outlet of Munsey's Lake and at upper end tributary terminus. (Bears SIN 2.)
TELROD COVE												
254-403	8/15/95	SCHROF	E			120	0	233	0			Fish were placed inside the barrier net on 8/12 (154) and 8/17 (33).
254-403	9/28/95	HANDER	P	F		0	0	0	0	50P		1440 HRS. Quick look, high water in creek. All pinks observed were at mouth. (Bears S/1 coy)

[a] From Brennan et al (1997).

Appendix J.3. Index aerial escapement surveys of Spiridon and Telrod Creek, 1996.[a]

Stream	Date MM-DD-YY	Observer	Visibility Str	Mou	Bay	Fish in Stream Sockeye	Coho	Pink	Chum	Build Up Fish Mouth	Bay	Observer Remarks
SPIRIDON RIVER												
254-401	7/18/96	HANDER	G			0	0	0	50			1510 HRS. High tide, average stream flow. Only surveyed clear water tributaries.
254-401	8/2/96	TONY CHATTO	F			0	0	0	800			1111 HRS. Low tide, low stream flow. 500 of the chums seen in clear water index area and other 300 seen in side channels above Munsey Lake confluence. No pinks seen in Munsey Lake Creek. Flow out of Munsey Lake was very low. 1 single bear.
254-401	8/3/96	PROKOPOWICH	P	F	F	0	0	0	0			Nothing seen on flats or in Weasel Cove. Visibility poor, river murky.
254-401	8/29/96	HANDER	G	F	G	120	0	5700	8000			1042 HRS. Low tide, low stream flow. Surveyed entire stream. Most all chums were in clear water tributaries and side sloughs. Pinks were in the main stream and in Munsey lake creek. Approximately 20 sockeye seen spawning in the side slough above confluence of Munsey lake creek and mainstem Spiridon. Other sockeye seen in Munsey Lake.
254-401	9/19/96	HANDER	G	P	P	60	2800	0	75			1240 HRS. Surveyed entire stream except from rapids to the mouth. Most coho just below Munsey Lake creek confluence. 1,000 Dollies in upper river.
254-401	10/16/96	JOHNSON	E			0	10600	0	0			1206 hrs. Surveyed entire system from upper forks to rapids. Low flow. Best survey conditions to date. Most fish in upper sections from Munsey's creek confluence to upper forks.

-Continued-

Appendix J.3. (page 2 of 2)

Stream	Date MM-DD-YY	Observer	Visibility Str	Mou	Bay	Fish in Stream Sockeye	Coho	Pink	Chum	Build Up Fish Mouth	Bay	Observer Remarks
TELROD COVE												
254-403	8/3/96	PROKOPOWICH				0	0	0	0			24 seiners. 3 tenders at terminal harvest area.
254-403	9/15/96	HONNOLD	E			10	0	238	0			Foot Survey. Pinks moved over barrier seine for escapement. Sockeye all jacks.

[a] From Brennan et al (*in press*).

Appendix K. Spiridon Bay Wildlife Surveys, 1991 - 1996.

Survey Dates	Number of Transects	Survey Dates	Number of Transects
30-Jul-91	8	15-Jul-94	8
28-Aug-91	8	5-Aug-94	8
18-Sep-91	8	25-Aug-94	8
16-Jul-92	8	20-Jul-95	8
24-Aug-92	8	8-Aug-95	8
		23-Aug-95	8
15-Jul-93	8		
15-Jul-93	8	16-Jul-96	8
3-Aug-93	8	8-Aug-96	8
31-Aug-93	8	5-Sep-96	8

Appendix L. Chum salmon stocks sampled and results for IHNV, 1982 - 1996.

Year Sampled	Source	IHNV Number	IHNV Percent	Location / Requestor
1982	Wells River	0/108	0%	Prince William Sound
1985	Skwentna River	0/150	0%	Susitna Drainage (Eklutna)
1985	Matanuska River	0/287	0%	Upper Cook Inlet (Eklutna)
1986	Eklutna River	2/60	3%	Upper Cook Inlet (Eklutna)
1986	Birch Creek	3/60	5%	Susitna River
1986	Talkeetna River	5/58	9%	Susitna River
1986	Chunilna River	5/59	9%	Upper Cook Inlet (Eklutna)
1988	Cottonwood Creek	0/57	0%	Kenai Peninsula (Tutka H)
1990	Klawock River	0/153	0%	Prince of Wales - SE AK
1993	Klawock River	4/26	15%	Prince of Wales - SE AK
1993	Daprakmiut River	0/8	0%	Nome
1991	Nome River	0/11	0%	Nome
1993	Nome River	0/30	0%	Nome
1994	Nome River	0/19	0%	Nome
1996	Sinuk River	0/6	0%	Nome
1992	Snake River	0/31	0%	Nome
1993	Snake River	0/31	0%	Nome
1995	Solomon River	0/32	0%	Nome
1996	Solomon River	0/2	0%	Nome
1996	Herman Creek	0/35	0%	Klehini River (Haines)
1995	Kaltag Creek	0/12	0%	University Alaska-Fairbanks
1996	Kaltag Creek	0/38	0%	University Alaska-Fairbanks
1994	Bay Creek	0/8	0%	Alaska Peninsula (King Cove)
1992	Toklat River	0/93	0%	Alaska Range (Clear H)
1993	Toklat River	0/127	0%	Alaska Range (Clear H)

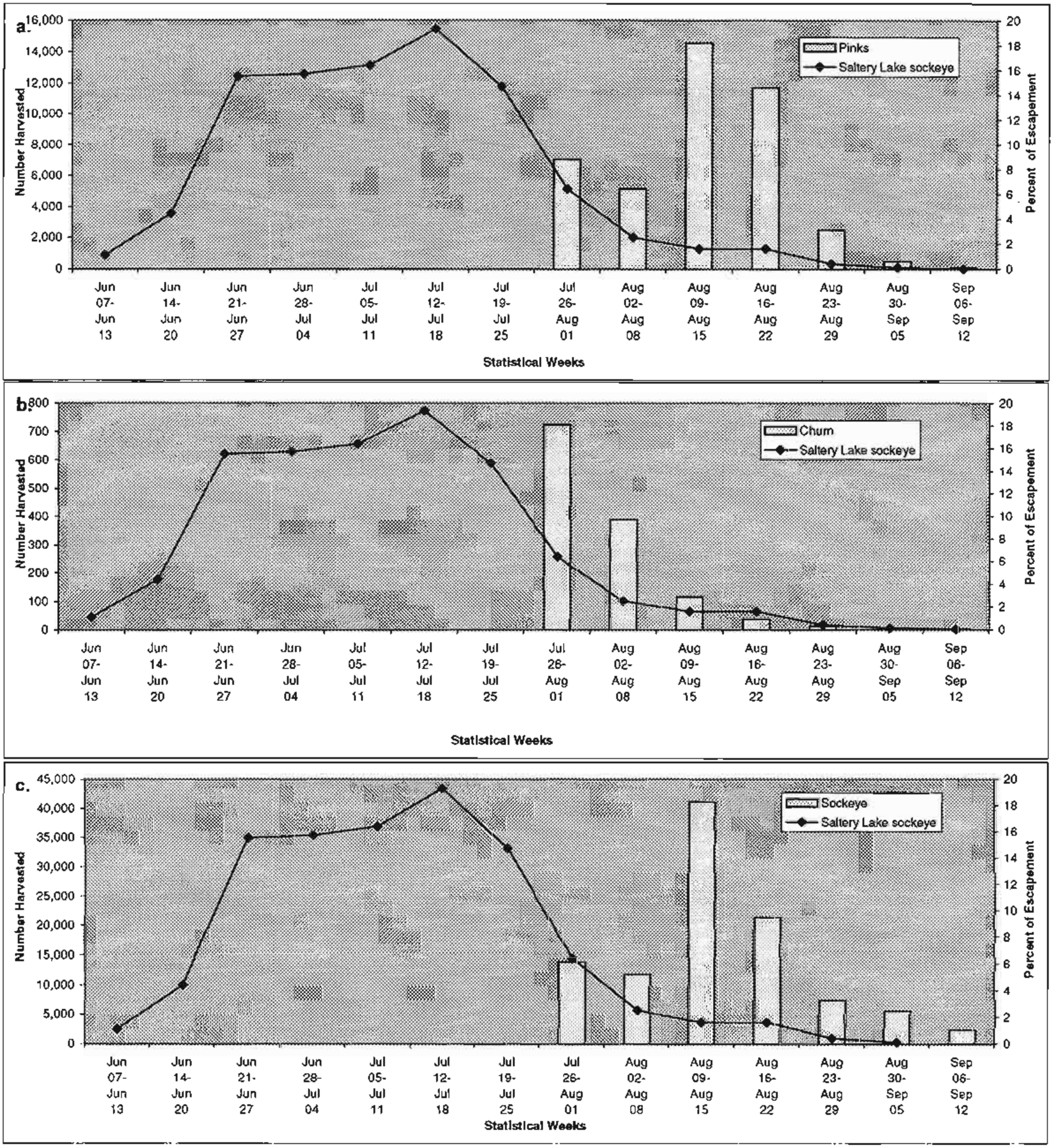
Appendix M. Estimated run timing of Spiridon Lake sockeye salmon on the westside of Kodiak Island and Telrod Cove for the brood stocks: Saltery Lake and Upper Station late run fish.[a]

	Westside Kodiak [b] Timing			Telrod Cove (Estuary)		
Brood Stock	Midpoint	Central	90%	Midpoint	Central	90%
Saltery	14-Jul	26-Jun	1-Aug	15-Jul	27-Jun	2-Aug
Saltery [c]	21-Jul	3-Jul	8-Aug	22-Jul	4-Jul	9-Aug
Upper Station, Late	10-Aug	23-Jul	24-Aug	11-Aug	24-Jul	25-Aug

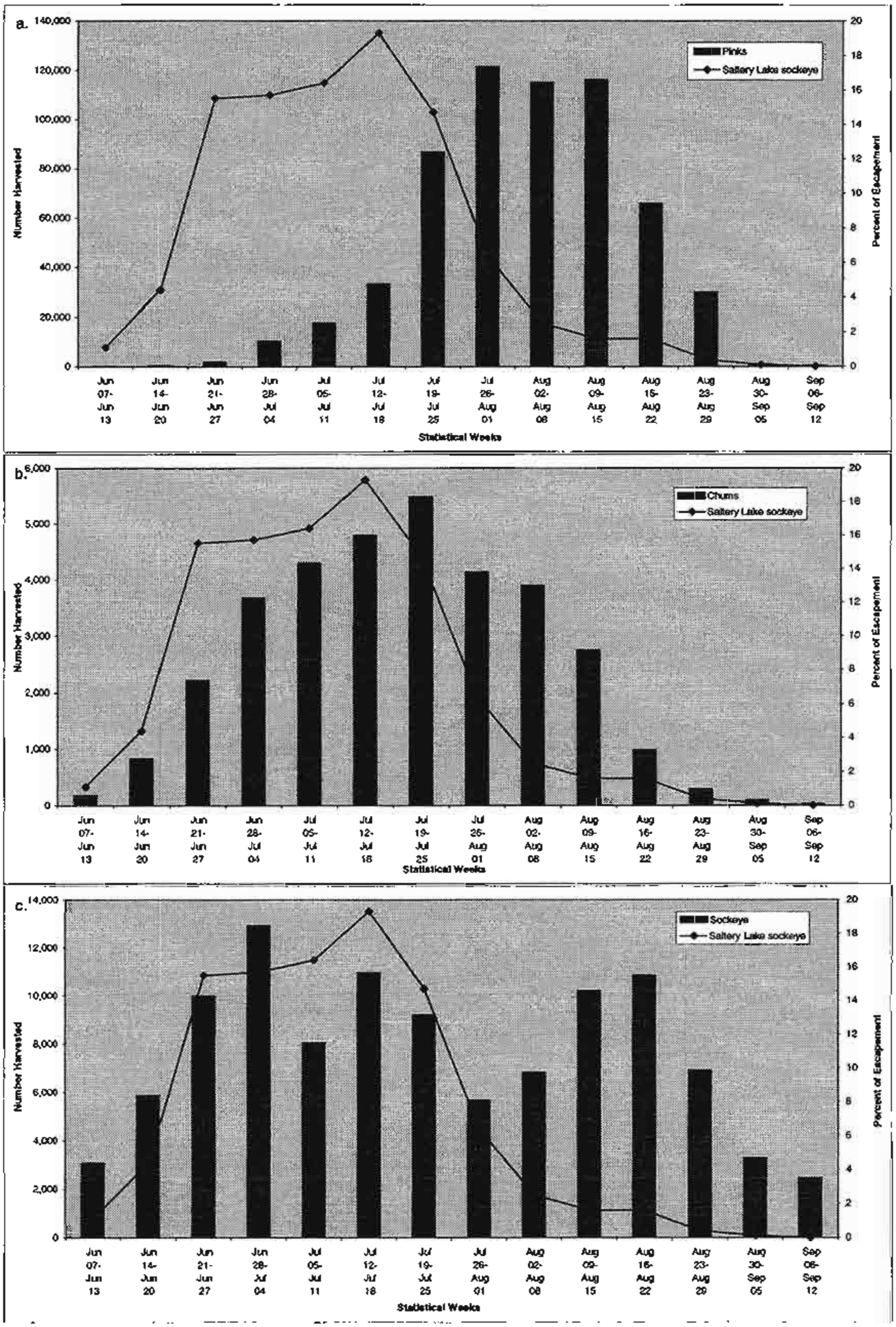
[a] From ADF&G (1994).

[b] The reference location for the westside is Cape Ugat.

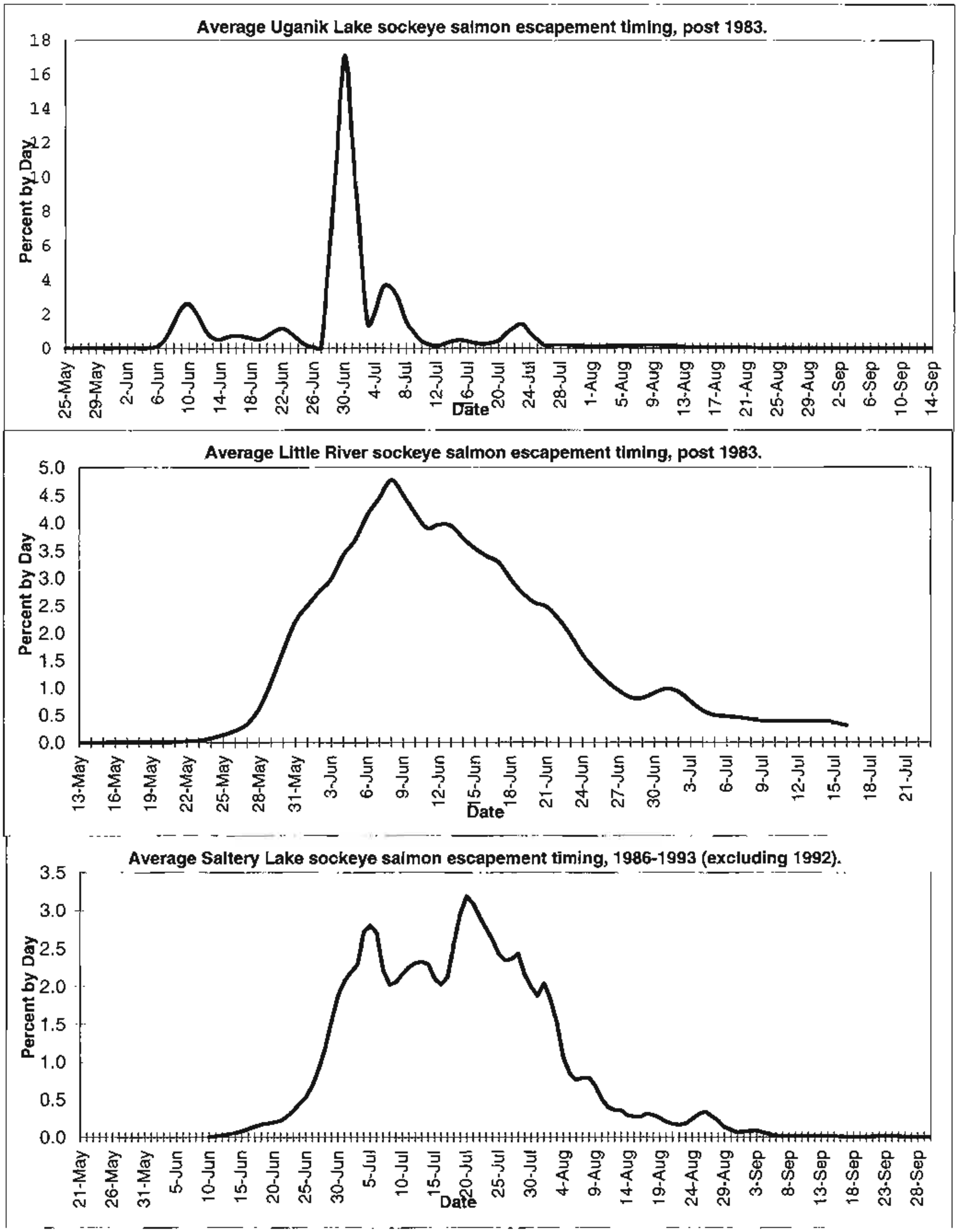
[c] The Saltery brood stock timing data are adjusted one week later in time from the baseline estimate. This change accounts for a perceived bias in the escapement count database.



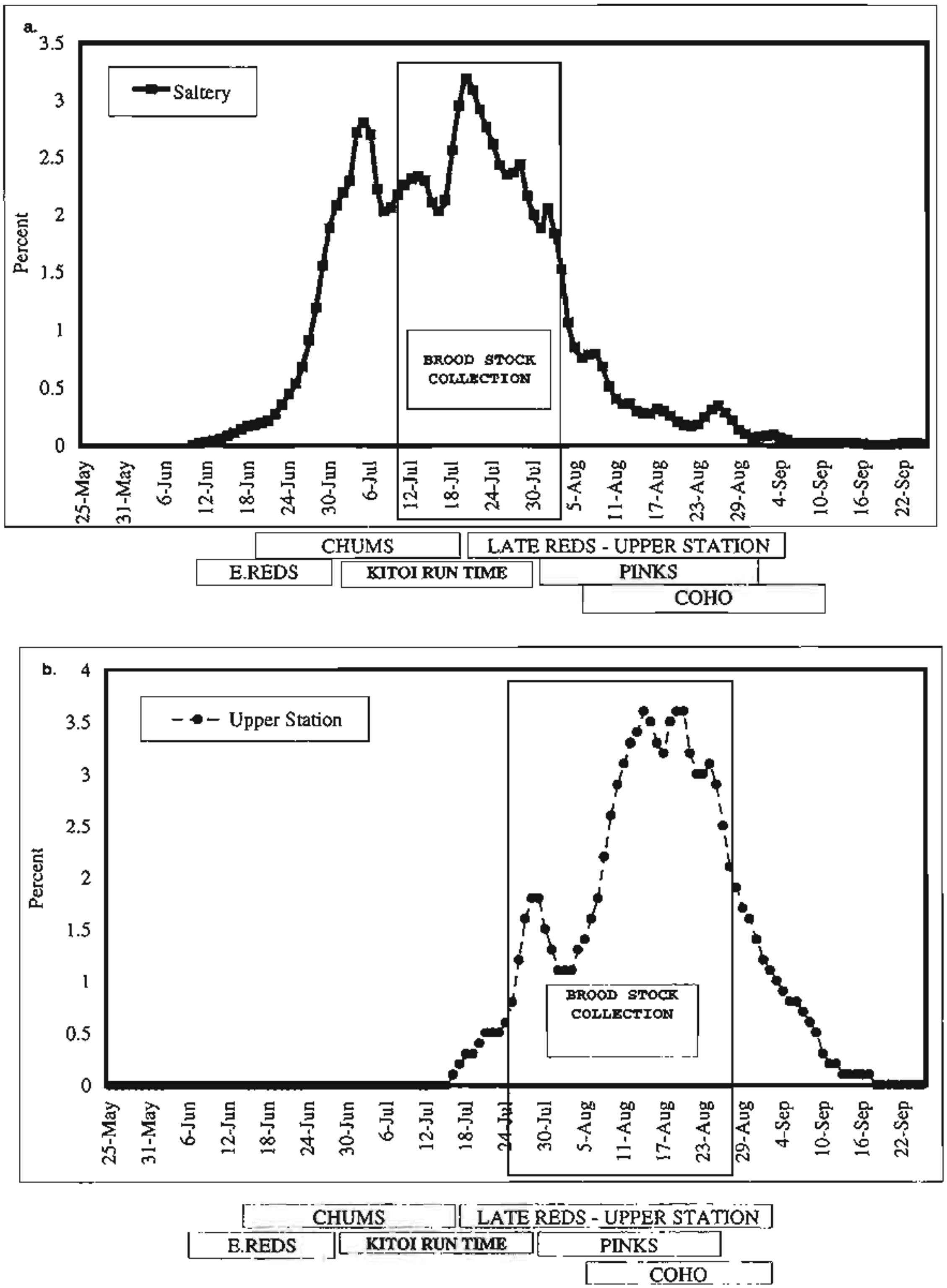
Appendix N.1. Estimated average (1984-1993) run timing of Saltery Lake sockeye salmon (ADF&G 1994) compared to the average harvest (1994-1996) for pink (a), chum (b), and sockeye salmon (c) caught in the Spiridon Bay Terminal Harvest Area (254-50); from Clevenger et al. (1997).



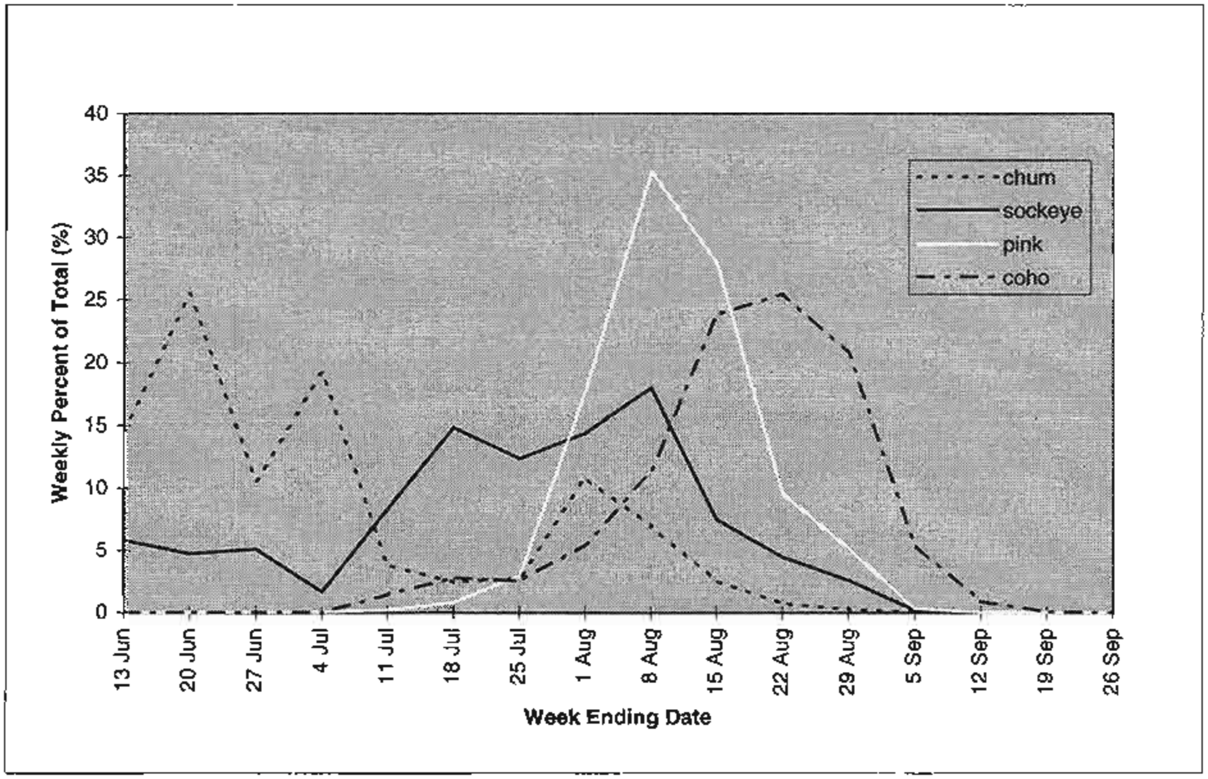
Appendix N.2. Estimated average (1984-1993) run timing of Saltery Lake sockeye salmon (ADF&G 1994) compared to the average (1986-1996) harvest for pink (a), chum (b), and sockeye (c) salmon caught in Spiridon Bay (254-40); from Clevenger et al. (1997).



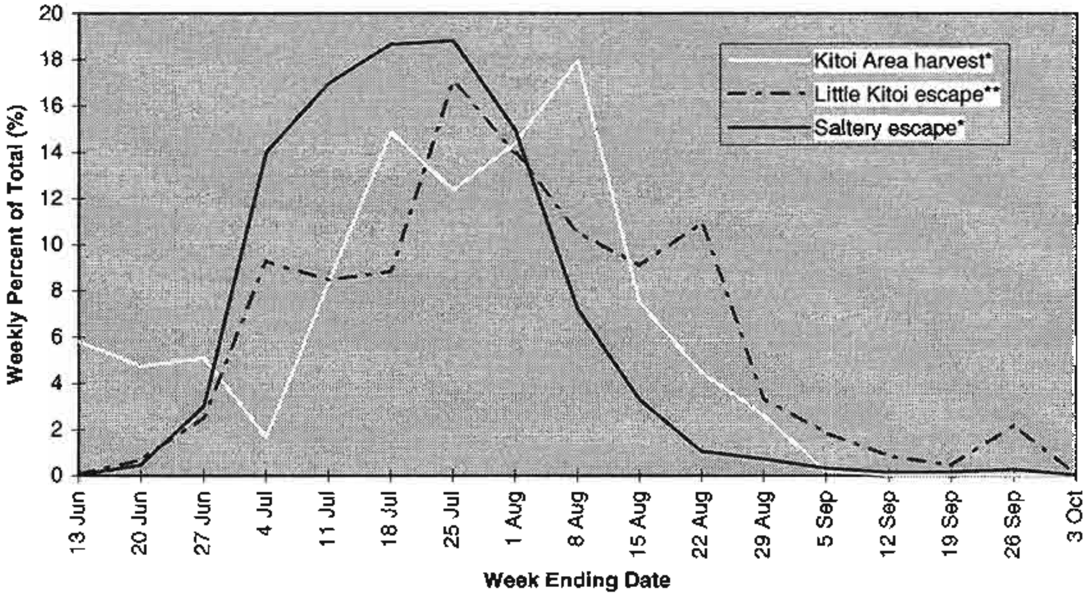
Appendix N.3. Uganik, Little River and Saltery Lakes sockeye salmon escapement timing, 1984-1994; from C. Hicks, ADFG, Kodiak, personal communication.



Appendix O.1. The run timing of salmon stocks in the Kitoi Bay Terminal Harvest Area compared to the late run Saltery sockeye salmon broodstock collection (a) and late run Upper Station sockeye salmon broodstock collection (b).



Appendix 0.2. Izhut, Duck, and Kitoi Bay Sections chum, sockeye, pink, and coho salmon average harvest timing, 1987-1996; from Hall et al. (1997).



*Kitoi harvest and Saltery ecscapement based on 1987-1996 data.
**Little Kitoi escapement based on 1992-1996 data.

Appendix 0.3. Izhut, Duck, and Kitoi Bay section sockeye salmon harvest timing (1987-1996) Little Kitoi Lake (1992-1996) and Saltery Lake (1987-1996) sockeye salmon escapement timing; from Hall et al. (1997).